Carrier Engineering Corporation

Carrier AIR CONDITIONING AND DRYING EQUIPMENT

Humidifying, Dehumidifying, Cooling, Drying, Air Washing, Automatic Temperature and Humidity Regulation

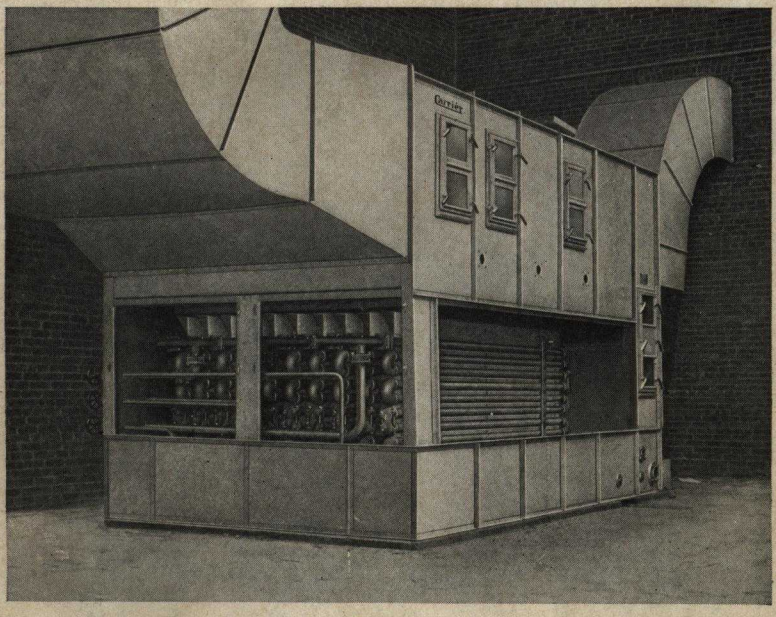
Carrier AIR CONDITIONING AND DRYING EQUIPMENT

39 Cortlandt Street, New York

BOSTON, MASS 176 Federal St. | PHILADELPHIA Land Title Bldg. | BUFFALO, N. Y. Mutual Life Bldg. | CHICAGO, ILL. Transportation Bldg.

Bulletin No. 101

Carrier
Dehumidifying Apparatus



One of three Carrier Dehumidifiers installed in the time fuse loading plant of British Munitions, Ltd., Montreal, showing doors at end and side of coil chamber removed for inspection of Baudelot coils. The liquid and suction headers with expansion and suction valves are shown at the left. Photo was taken during construction before water piping and pump were installed.

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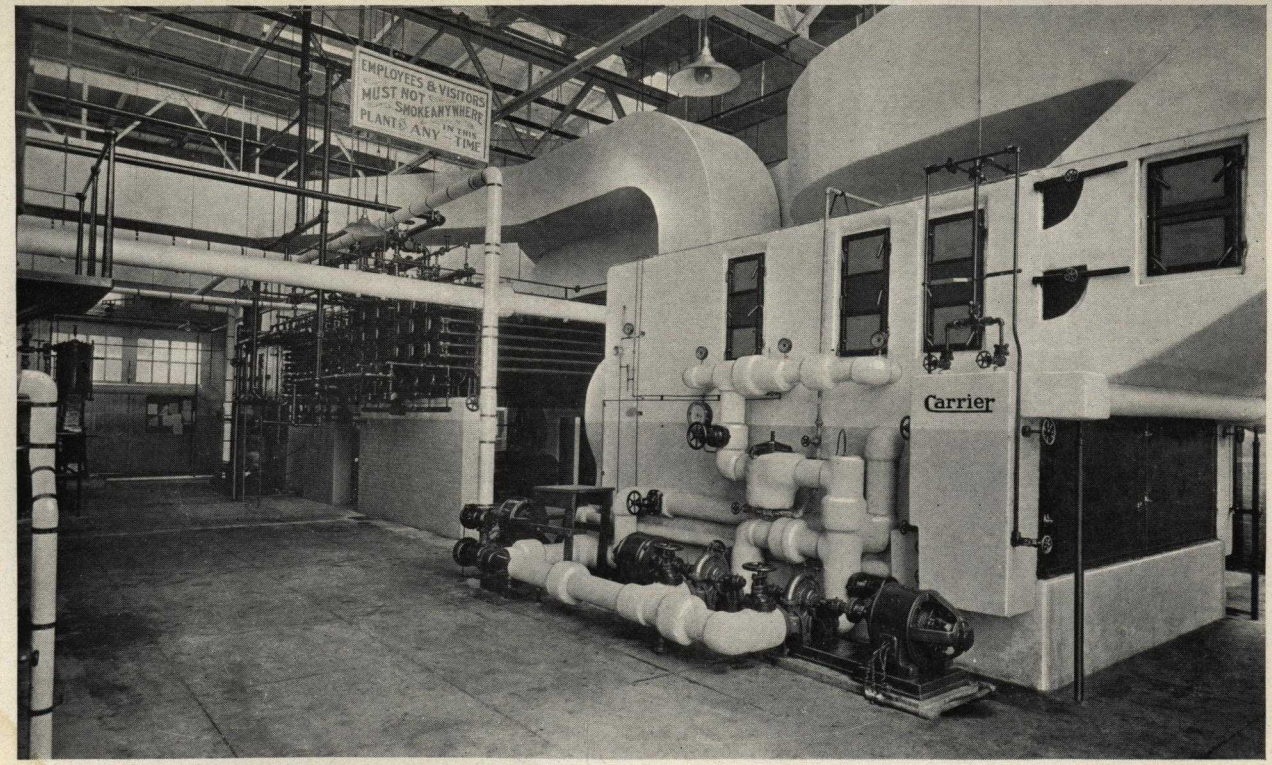


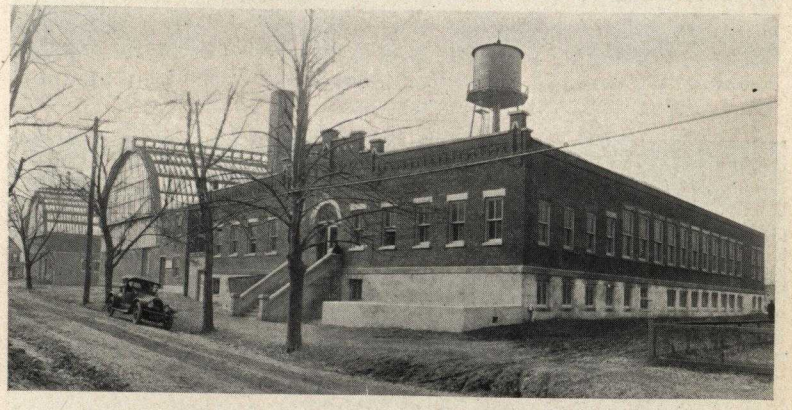
One of these Carrier Dehumidifier Installations made by us in the plant of the Walco Company, Providence, R. I. The Condensers are shown upon piers at the left.

Atmospheric Dehumidifying

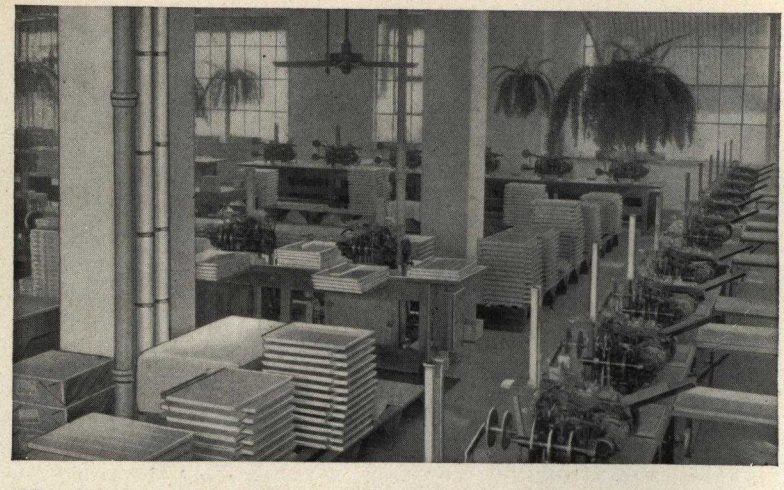
THE removal of water vapor from the air, may be accomplished in two ways: first, absorption of the vapor by some substance having great affinity for water, such as sulphuric acid or calcium chloride, and *second*, condensation by contact with cold surfaces or a liquid.

The Absorption Method is extensively used on a small scale in laboratories and in extremely small installations, but has never been successful on a large scale or in industrial processes because of the attending difficulties. These difficulties include handling the dehydrant, bringing the dehydrant into intimate contact with *all* of the air, reclaiming the dehydrant by removing the water absorbed and preventing great loss of the dehydrant with removal of the water.

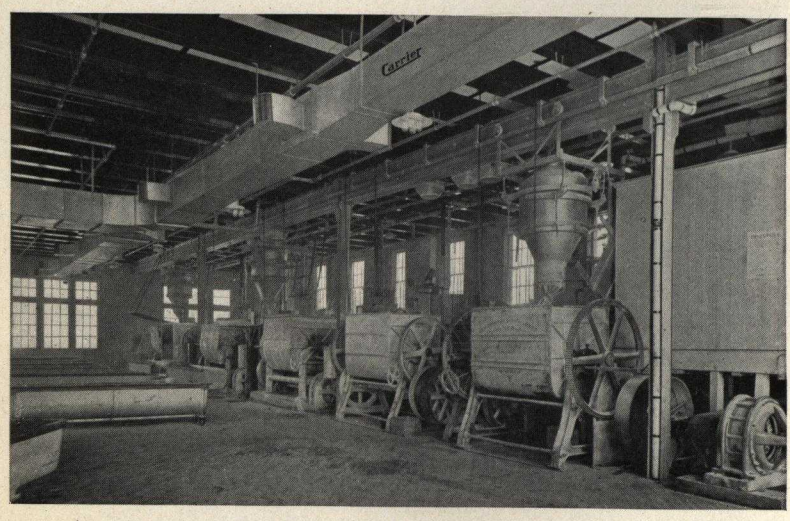
The greatest difficulty, however, is due to the natural law of latent heat of water vapor. Mere heating of the air increases its capacity for holding moisture and its relative humidity is



Willat Film Studios, of the New York Motion Picture Co., Fort Lee, N. J., in which Carrier Dehumidifying Apparatus improves quality of the films by keeping dust out of the air and by keeping the temperature and humidity percentage right for proper drying. In this service, the Carrier equipment maintains temperature within a variation of two degrees, is absolutely automatic in doing so and is equally dependable in dehumidifying. The Vitagraph Co., Brooklyn, N. Y., who have a similar installation for similar service tell us that Carrier apparatus is the most satisfactory that they ever used for the purpose. The dehumidifier in the Willat Studios is shown partially installed and completely installed, on pages 44 and 45 respectively.



Chewing gum department of the Beechnut Packing Co., Canajoharie, N. Y. A model factory, in which dehumidifying, temperature regulation and the removal of sugar and other dust from the air are accomplished through the use of Carrier Dehumidifying Apparatus, which also enables the plant to operate continuously through the summer even in the most humid weather.



Mixer room of Gordon-Pagel Bakery, Detroit, Mich., showing ducts of the Carrier Dehumidifying System, which purifies the air perfectly, regulates the temperature to within one degree, and helps uniformity of product. *See also page 24.*

Factory building of the American Druggists Syndicate, Long Island City, N. Y. Carrier Dehumidifying Apparatus is installed to allow the packing of certain of their goods in the humid weather of summer.

lowered without changing its vapor content. Water vapor cannot be condensed or absorbed without liberating the latent heat; if the vapor is condensed the latent heat is absorbed by the condensing medium. If the vapor is absorbed by some hygroscopic substance, the latent heat is liberated and raises the air temperature thus lowering its relative humidity both by the removal of vapor and the increase of temperature. The greater the absorption, the greater will be the rise in the air temperature and correspondingly lower will be the relative humidity. As the relative humidity is lowered the rate of absorption is decreased, so the removal of considerable water vapor from large quantities of air, which must necessarily be done quickly in order to be at all practical, is made exceedingly difficult if accomplished at all.

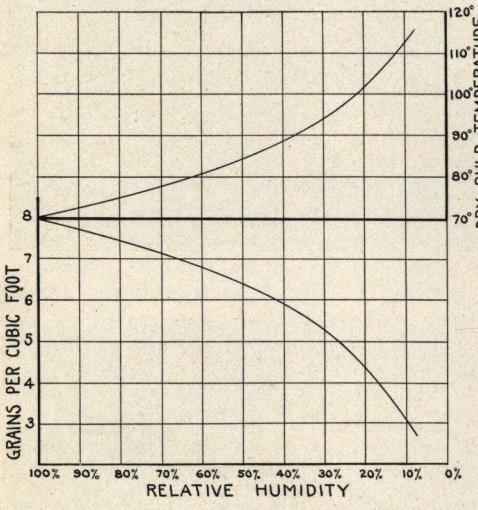
To illustrate: Assume that a manufacturing process requires fresh air with 50 per cent relative humidity and 70° temperature (4 grains moisture contained per cubic foot) when the outside atmosphere is at, say 85° temperature and 60 per cent relative humidity (7.64 grains moisture contained per cubic foot).

The removal of 3.64 grains of moisture from every cubic foot of air would be required. The liberated latent heat from this vapor would raise the air temperature approximately 3.64 x 8 = 29° F, and these conditions would prevail:

Temperature of air entering absorber..... 85°
Temperature rise in absorber..... 29°

Temperature of air leaving absorber.....114°

Air at this temperature has a relative humidity of less than 14 per cent, and at this low humidity the rate of absorption would be exceedingly slow, even with chemicals having a high degree of concentration and with means for procuring very close contact of air and the dehydrant.



Even if the entering air is at 70° (see diagram) and containing 8 grains of vapor per cubic foot (saturation at 70°), and half the vapor is to be removed to reduce the content to 4 grains as will be noted from the diagram, the temperature rise would be about 34°, giving an air temperature of 104° and a relative humidity of about 16 per cent. The air would then have to be cooled by some means to 70° in order to be of use for the plant under discussion.

Handling and distributing the dehydrant for thorough contact is almost impossible from a practical standpoint, and concentration of the absorbing medium without great loss is to say the least not simple, but very necessary if this method is used at all. The cost of continuously using new chemical is prohibitive.

Due to the use in laboratories of such dehydrating chemicals as sulphuric acid and calcium chloride, this method has been tried more often than all others combined, yet as far as we know, there has never been even a single successful large installation.

The Condensation Method depends in principle upon cooling the mixture of air and vapor to a low temperature so that a portion of the vapor will be deposited. This, as previously stated, is accomplished in two ways, either by contact with cooled surfaces, or by direct contact with a cooled liquid.

Surfaces inside of which cold water, brine or ammonia are circulated have been in use for many years and until recently were the basis of the only practical systems for commercial purposes. For some classes of work, the use of such surfaces is still better than other methods, but in more recent installations, the surface method has given way to direct contact with the cooling liquid.

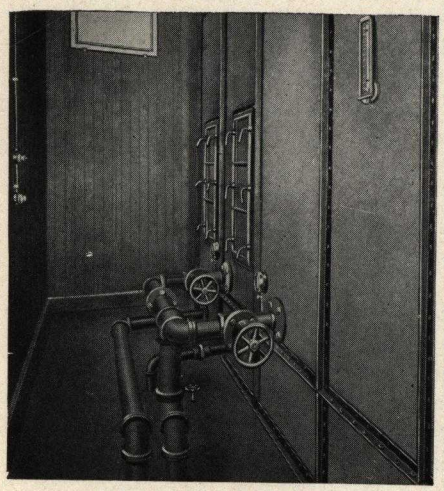
The idea of passing the air to be dehumidified, over cold surfaces so that the air and vapor would be cooled to a low temperature, and the condensed vapor deposited on the cooling surfaces, has been utilized in many forms of apparatus. The surface is kept cool by cold water from a well or other natural source or by artificially cooled brine or some such refrigerant, as ammonia or carbon dioxide. With this method, the heat of air and vapor, both sensible and latent, is removed, but, although the vapor also is removed effectively, the system in any of its forms has many disadvantages. A large amount of surface is required to do the work efficiently and the space requirements are correspondingly great. Accurate regulation of the moisture content of the air leaving the system is exceedingly difficult, and automatic regulation is impossible.

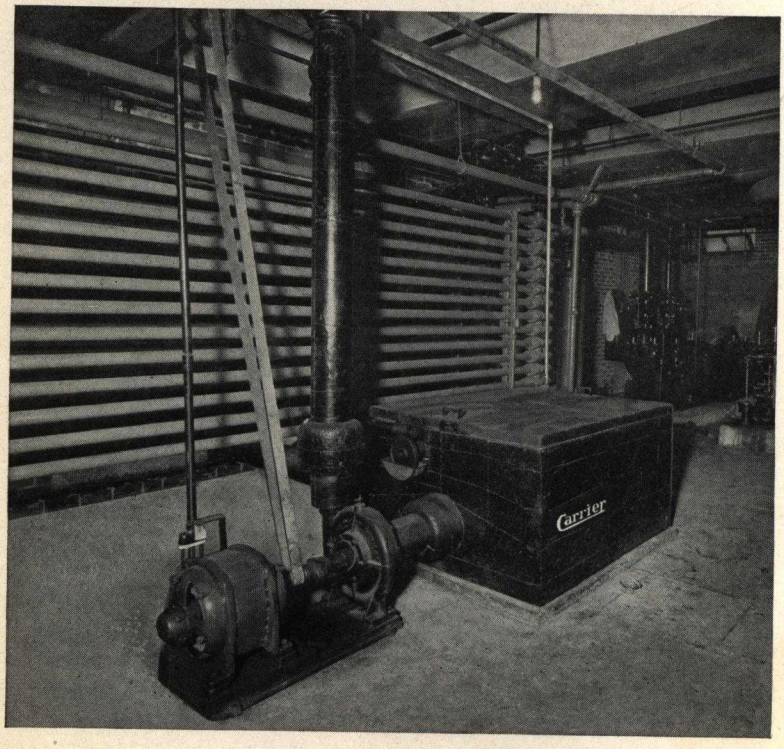
The new Baltimore Hotel, Kansas City, Mo. A Carrier Dehumidifier is installed for cooling the grill room.

Carrier Dehumidifier used in the candy factory of The Geo. Close Co., New York, to keep the chocolate packing room and the stock room cool during warm weather. Without automatic regulators for controlling temperature in the cold rooms, the range is kept within four or five degrees, which is sufficiently close for the work. The humidity remains practically constant and sufficiently low to prevent any discoloration of the chocolate coating, and at the same time is not low enough to cause discomfort to workmen.

The condenser and rotary strainer are shown in the lower picture.

(See also page 9)



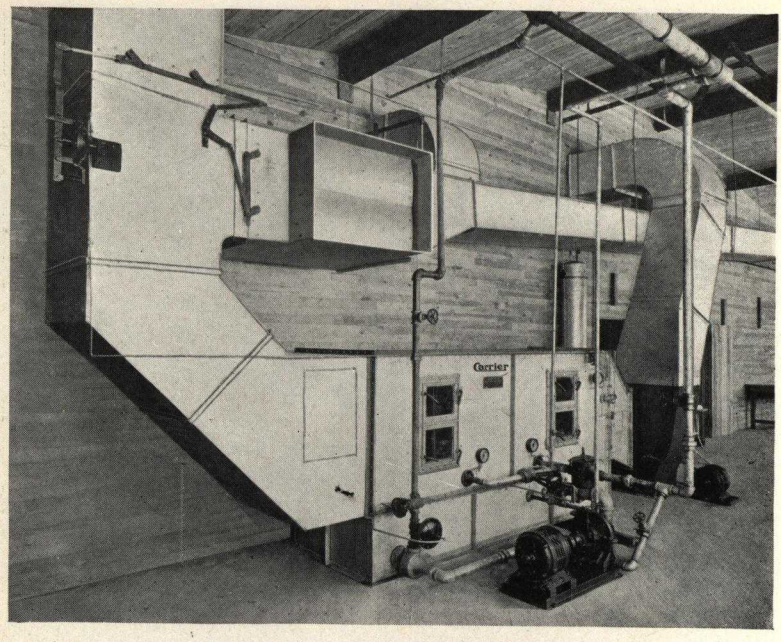


Showing three air ducts of the Carrier Dehumidifying System in the candy factory of the George Close Co., Cambridge, Mass. The air is kept sweeter and cleaner and the humidity much more constant than with the dehumidifying system which Carrier Apparatus supplanted. After three years' experience with the Carrier System, the owners tell us they are greatly pleased, consider the investment profitable, and have had very slight maintenance expense. *(See also page 8).*

If refrigeration is used as a means of keeping the surface cold, there is the additional disadvantage of frosting, which so impairs the efficiency of the surface that at intervals the surface must be heated and defrosted. The plant must be shut down during the defrosting period or enough excess surface must be provided to enable the work to be carried on by part of the surface while the rest is out of use.

The Direct Contact Method of bringing the air and vapor into sprays of cold water or brine is not new, being based upon the principle of a barometric condenser which works at atmospheric pressure instead of under a vacuum.

Those who are wont to consider application of a direct spray to air for the purpose of dehumidification, as being at least not orthodox, should recall that atmospheric humidity is nothing more nor less than a mechanical mixture of low temperature steam and air, subject to exactly the same physical laws as steam



Carrier Dehumidifier at the plant of the Gathmann Ammunition Co., Texas, Md. This installation uses well water for dehumidifying and is completely equipped with automatic regulation to maintain conditions constant the year around.

at higher temperatures, except that the heat of the air under certain conditions modifies the working of these laws.

The application of a direct spray to air for the purpose of dehumidifying possesses the following very marked advantages over the coil surface method:

First, Frosting is entirely eliminated.

Second, As the air and water can be brought in a single stage to the same temperature, a higher suction pressure on the compressor can be maintained with consequent saving in power.

Third, the air is thoroughly cleansed by the washing.

Fourth, more accurate regulation is permissible, and automatic control, which is very simple and positive, may be employed.

Fifth, much less space is required.

Sixth, where well water is available in sufficient quantities, much of the work can be done without refrigeration.

Seventh, more efficient and thorough heat transfer is possible, due to the intimate contact of the cold water and air. The temperature of the air and the liquid leaving the dehumidifier are the same.

Calculation of the Amount of Heat to be Removed in Cooling Air:*—The heat removed in cooling air from the dry bulb to the wet bulb temperature is exactly equal to the heat required to evaporate the water necessary to produce saturation at the wet bulb temperature. This indicates that the really important consideration in the cooling of air is the wet bulb temperature. If the wet bulb temperature is known, the humidity, or the dry bulb temperature, is of no real importance and is not needed for the purpose of calculation.

The following extracts, Table 1, from a series of tests made by Mr. W. H. Carrier conclusively prove the above statements:

TABLE No. 1

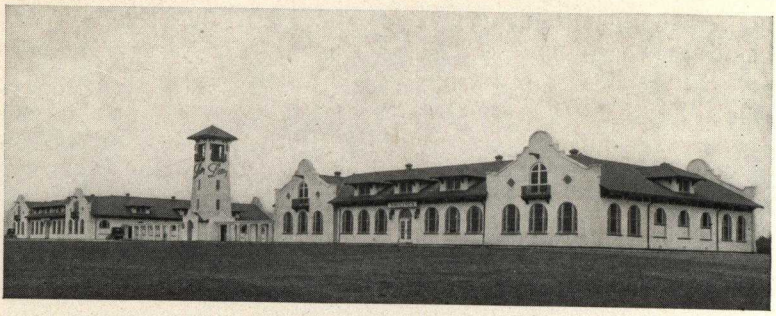
Air Temperature, Degrees Fahrenheit			Water Temperature, Degrees Fahrenheit	
Entering		Leaving		
Wet Bulb	Dry Bulb	Saturated	Entering	Leaving
80	81.	61.1	58.8	64.4
80	84.	60.8	58.8	64.4
80	87.	61.1	58.8	64.3
80	84.	60.9	58.8	64.3
80	90.5	60.9	58.9	64.1
80	93.5	60.8	58.8	64.1
80	96.	60.7	58.8	63.9
80	98.	60.8	58.9	64.0
80	104.5	60.7	58.9	63.9
80	107.	61.2	58.9	64.0

In the above test, only cold water was used and the moisture content of the atmosphere was reduced. The following test, Table 2, shows the effect when adding moisture:

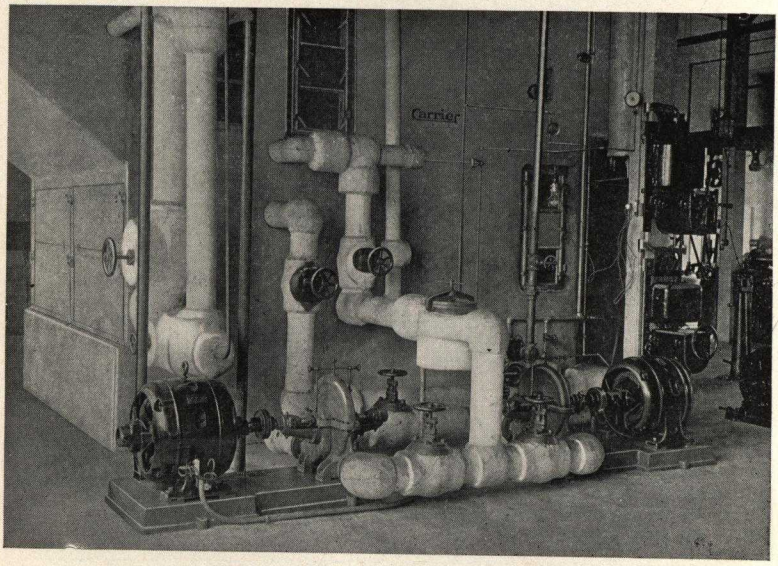
TABLE No. 2

Air Temperature, Degrees Fahrenheit			Water Temperature Degrees Fahrenheit	
Entering		Leaving		
Wet Bulb	Dry Bulb	Saturated	Entering	Leaving
75	77	91.5	110.1	88.9
75	80	91.5	110.1	88.4
75	90	91.5	110.1	88.5
75	95	91.3	110.1	88.4
75	100	91.3	110.1	88.4
75	105	91.5	110.1	88.4

*Abstracted from a paper read by J. I. Lyle, member American Society Mechanical Engineers, and an officer of the Carrier Engineering Corporation, before the American Society of Refrigerating Engineers.



Greenfield, Ind. plant, Eli Lilly & Co., Carrier equipped as a result of satisfaction in their Indianapolis plant.



Carrier Self-Contained Dehumidifier in a plant for loading shrapnel time fuses. These fuses must be capable of setting for explosion of the shell anywhere from within 16 feet of the muzzle of the gun to a distance of several miles away, while the shell is traveling at a velocity of 1700 feet per second, or about 20 miles per minute. Two shells set for exploding at one mile and fired consecutively, must function within 40 feet of each other. The powder used in a time fuse is very hygroscopic, and the accuracy of firing is absolutely dependent upon conditioning the powder. The humidity of the atmosphere in which the fuse is loaded must therefore be maintained within a total variation of less than two per cent. The above installation is one of over a dozen plants installed by us for this purpose during 1915 and 1916.

The dry bulb temperatures were varied from 77 degrees Fahr. to 105 degrees Fahr., but the wet bulb temperatures were maintained constant at 75 degrees. The flow of water was constant, as was the air handled. It will be noted that: *first*, the leaving temperature of air was practically constant in all cases, although in three cases the air was heated, and in the other three it was cooled; and *second*, the temperature drop of the water was also practically constant, showing that the heat removed was the same in each case.

In contrast with the above it is interesting to note in Table 3 the effect of varying the wet bulb temperature with the dry bulb temperatures constant. Here, although the entering wet bulbs

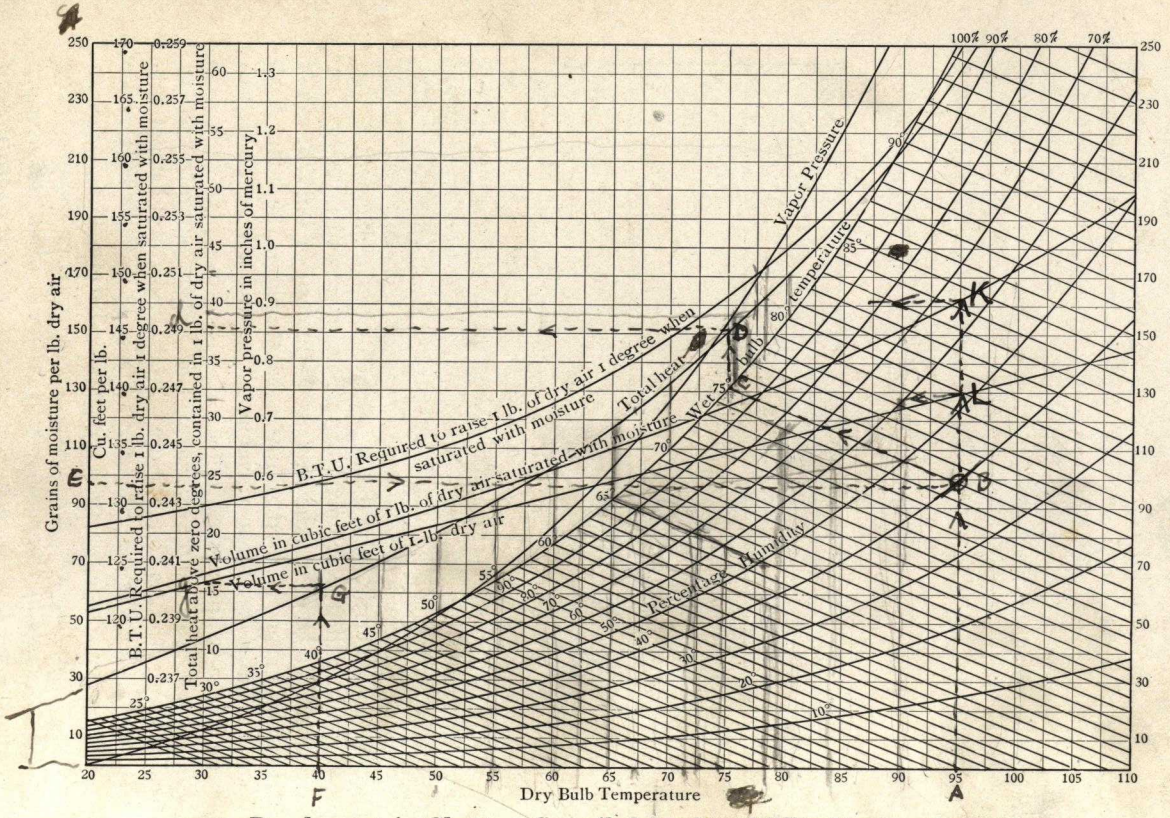
TABLE No. 3

Air Temperature, Degrees Fahrenheit			Water Temperature Degrees Fahrenheit	
Entering		Leaving		
Wet Bulb	Dry Bulb	Saturated	Entering	Leaving
75	90	95.7	110.1	93.2
80	90	97.8	110.1	94.1

are only 5 degrees apart, there is a difference in the final temperatures of 2.1 degrees Fahr. That the amount of heat removed was different is shown by the difference in the rise in temperature of the water.

The usual way of calculating the amount of heat to be removed in the cooling of air is to estimate separately the sensible heat of the air cooled, the latent heat of condensation, and the heat for cooling the condensed liquid. This method, however, admits of considerable error. In the first place, the specific heat of air is a variable, and, for ordinary temperatures, recent investigation has shown it to be approximately 0.241 instead of 0.2375, which has been so generally used. In the second place, the latent heat of condensation is also a variable, changing with each degree change in the temperature.

A much simpler, and at the same time a very accurate, method of calculating heat, is to make use of a curve of total heat of saturated air, which was described in paper by Mr. Willis H. Carrier of the Carrier Engineering Corporation, before The American Society of Mechanical Engineers. Mr. Carrier says: "*The cardinal principle of this method is, that for a given temperature of evaporation—that is, for a given wet bulb temperature—a pound of air contains a fixed and definite amount of heat, regardless of the dry bulb temperature or of the moisture contents. This means that the wet bulb temperature is the rational and con-*


Grains of moisture per lb. dry air
Cu. feet per lb.
B.T.U. Required to raise 1 lb. dry air 1 degree when saturated with moisture
Total heat above zero degrees, contained in 1 lb. of dry air saturated with moisture
Vapor pressure in inches of mercury
B.T.U. Required to raise 1 lb. of dry air 1 degree when saturated with moisture
Volume in cubic feet of 1 lb. of dry air saturated with moisture
Volume in cubic feet of 1 lb. dry air
Total heat
Wet bulb temperature
Vapor Pressure
Percentage Humidity
100% 90% 80% 70%
Dry Bulb Temperature
E
F
A
D
K
L
G

Psychrometric Chart. Compiled by Mr. Willis H. Carrier.

Example intended is for mechanical refrigeration temp. conditions.

venient measure of the total heat content of the air, both latent and sensible. For example, an ordinary recording thermometer with the bulb covered with a wetted wick, over which a current of air is circulated, could be made to record B. t. u. contents per pound of air by graduating the record in terms of B. t. u. instead of in degrees temperature. Consequently, in dehumidifying, the maximum refrigerating load will occur at the maximum wet bulb temperature, relation of dry bulb temperature to moisture contents being immaterial."

This curve, shown on page 14, is based on the weight of a pound of dry air, which is saturated at the given temperature. By the use of this curve, by taking the difference between the total heats of the final temperature or dew-point to which the air is cooled, and the total heat of the air saturated at the entering wet bulb temperature, the amount of heat to be removed is very quickly obtained. The number of cubic feet of dry air and dry air saturated per pound are also shown by the curve, which adds to its value for practical use.

It will be noted that the ratio of cubic feet per pound of dry air for various temperatures is indicated by straight line, while cubic feet per pound of dry air saturated is represented by curve.

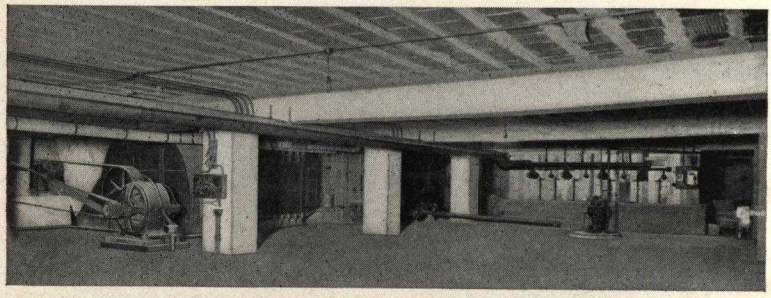
The number of cubic feet of the mixture of air and vapor when not saturated may be found by taking the difference between the number of cubic feet for dry and saturated conditions and multiplying this difference by the percentage of saturation of the mixture, and adding this to the cubic feet per pound of dry air.

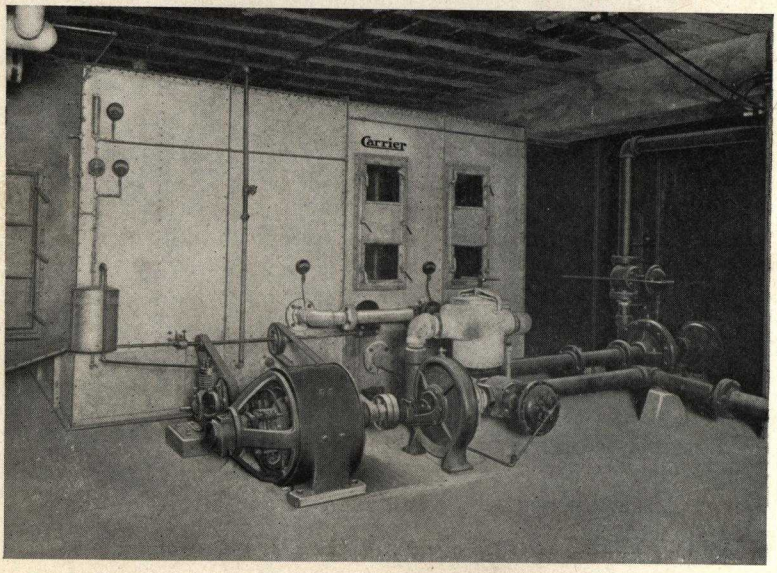
To illustrate: Required a plant of a capacity of 13,000 cubic feet of dry air per minute, which enters the apparatus at a temperature of 90 degrees with 60 per cent relative humidity. Referring to the chart, at 90 degrees Fahr., 14.54 cubic feet of dry air is saturated per pound. Since there are 13.86 cubic feet of dry air per pound, the difference, $14.54 - 13.86 = 0.68$ cubic feet, is the increase in volume due to the water vapor necessary for saturation. As the mixture is 60 per cent saturated, $0.68 \times 0.60 = 0.408$, the number of cubic feet of vapor in the mixture per pound of dry air, and $0.408 + 13.86 = 14.268$, the number of cubic feet of the mixture at 90 degrees Fahr. and 60 per cent relative humidity per pound of dry air.

Then $\frac{13{,}000}{14.268} = 887$ pounds of dry air.

To procure the total heat from the chart, let it be assumed that the air entering at 90 degrees Fahr. and 60 per cent humidity must be reduced to 50 degrees Fahr. It will be found that 90 degrees and 60 per cent relative humidity corresponds on the chart to a wet bulb temperature of 78¼ degrees Fahr. Now, by follow-

ing along the oblique 78¼ degree Fahr. line to the curve of saturation, and then vertically to the total heat curve, the total heat is found to be equal to 40.75 B. t. u. per pound. By finding 50 degrees Fahr. on the saturation curve and tracing it vertically we find its total heat is 20.2 B. t. u. Now, 40.75 — 20.252= 20.5, the number of B. t. u. per pound of dry air, and 20.5 (B. t. u.) × 887 (pounds) = 18,183, the number of B. t. u. to be removed from 13,000 cubic feet of air at 90 degrees Fahr. and 60 per cent relative humidity, in order to reduce it to 50 degrees Fahr. and saturation.





Two views of the Carrier Dehumidifying Apparatus installed in the plant of the Hershey Chocolate Co., Hershey, Pa. In addition to dehumidifying, this apparatus gives very efficient heating and cooling. The temperature regulation, when set for 68° has been within two degrees and is as close as desired.

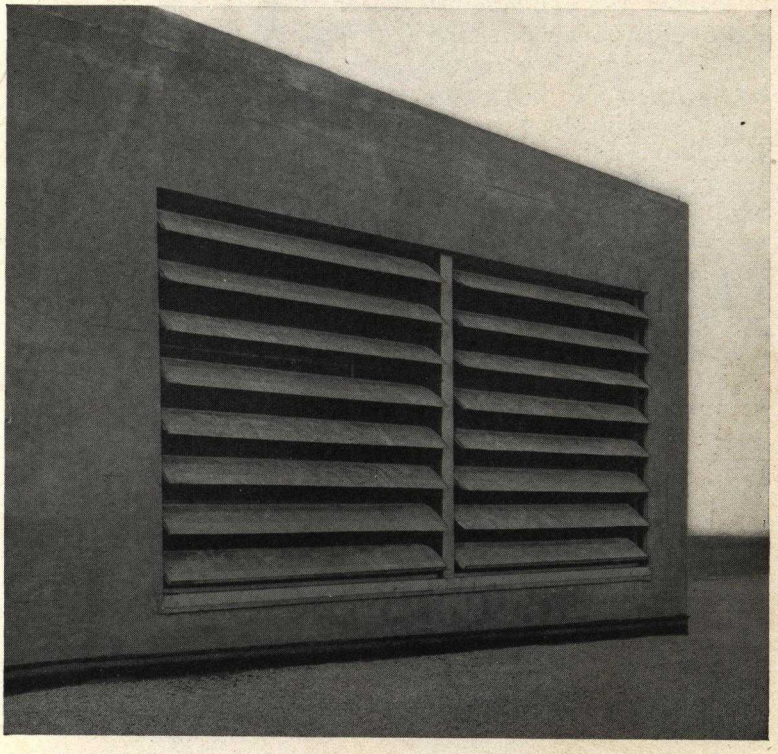
Operation of the Carrier Dehumidifying System

The Carrier Dehumidifying System as installed in an industrial plant usually comprises the following elements:

Fresh and return air dampers, air mixing chamber, a dehumidifier, a heater, a fan, distributing ducts and automatic regulators for both temperature and humidity.

Each installation is an engineering problem within itself. The following pages therefore offer only a general description of important features. Details are varied to form the combination which best meets specific requirements.

The Air Supply is taken either from the outside of the building or returned from the inside as may be required. In cool or moderate weather the supply comes from the outside, while in cold or extremely hot weather a greater part is taken from the inside to obtain a maximum saving in heat or refrigeration.



Fresh air dampers of Carrier System in penthouse of a large factory building.

Dampers are provided in the fresh and return air inlets and automatically regulated to take from each source the proportionate amount of air to give the desired temperature. Usually additional dampers are provided in the fresh air inlet so this may be closed absolutely tight in the very humid hot weather of summer.

The Dehumidifier Chamber thoroughly washes and cools the air by mixing with it a minutely divided spray of water coming from a large number of nozzles. The water is so minutely atomized and so thoroughly mixed with the air that there is a thorough interchange of heat from the air and the condensing vapor to the water. The air is thus cooled and the vapor condensed to the dew-point desired.

The air on its way out of the dehumidifier passes between eliminator plates which separate the air and water, retard the latter, and leave the outgoing air cool, clean and carrying just the amount of water vapor desired.

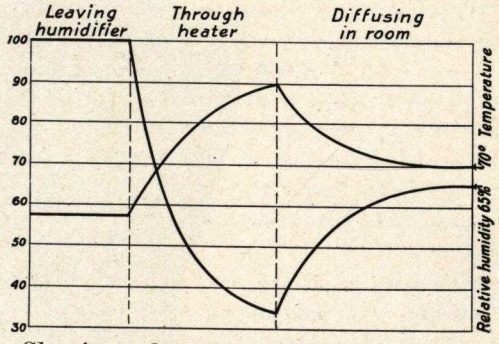
Fixing the Amount of Water Vapor—The amount of water vapor the air can carry is dependent upon its temperature, so if the air is saturated, that is, has all the water vapor it will hold without any surplus the amount of moisture it will carry is also regulated by regulating its temperature. A Carrier Dew-Point Thermostat is placed in the air outlet duct in the path of the saturated air, as it leaves the dehumidifier. This thermostat regulates the pressure of compressed air on a diaphragm which operates the fresh and return air dampers described on page 41, thus mixing the fresh, dry air from outside with the warm moist return air from the building at just the right temperature.

The thermostat may also regulate the compressed air pressure on the diaphragm of a mixing valve which acts to vary the temperature of the spray water.

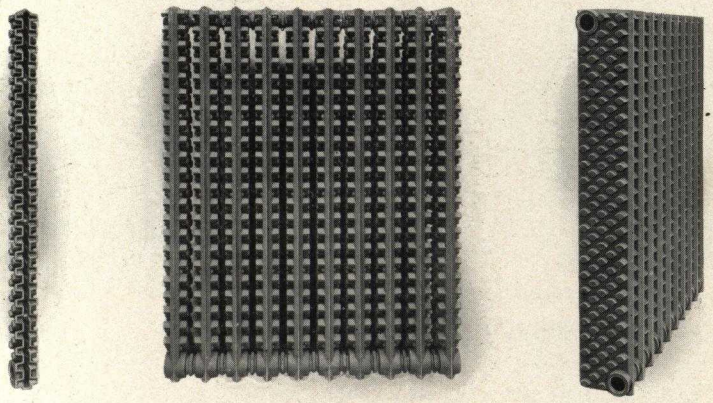
In this manner every cubic foot of air going to the building carries with it the same amount of water vapor, giving a uniform condition which cannot be secured by any other method.

Heating in new buildings or those not provided with a separate heating system, can be provided by warming the air before it is delivered to the building. The location of the steam coils used for warming the air depends upon the local conditions of the installation. If only one room is to be conditioned, the heating coils are usually placed between the dehumidifier and the fan, while if several rooms or floors are to be treated, the heater may be divided so that one room may be treated while another is being cooled. Cast iron Vento radiation is used almost exclusively on account of its rust resisting properties and hence its longer life.

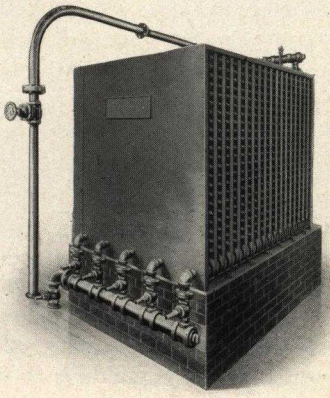
It does not matter how the heating of the air is accomplished after it is saturated nor how high it is heated, provided it is afterwards cooled to the required temperature. For instance, the air may be saturated in winter at 60 degrees F. and then be heated to 90 degrees F. which would lower its relative humidity to 46 per cent (see sketch). On entering the room it supplies heat to the cold walls, windows, etc. and its temperature drops to 70 degrees (that of room) and then the relative humidity would be 70 per cent.



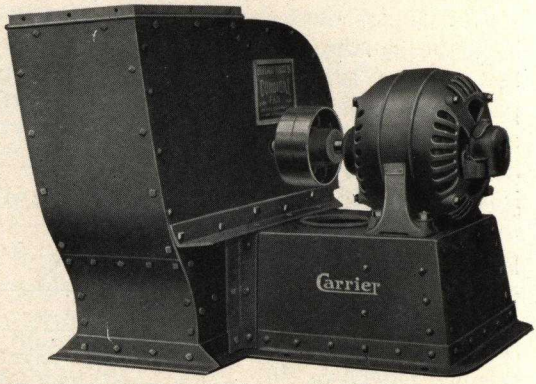
Showing the effect of the heater on temperature and humidity conditions.



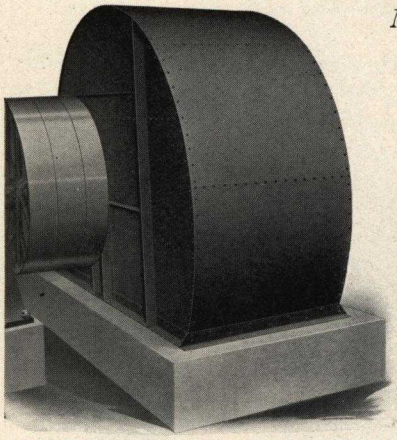
Cast iron Vento radiation section and the completely assembled heating unit.



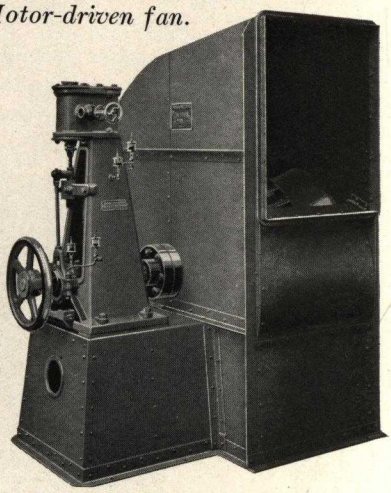
The Fan. The air usually goes from the dehumidifier to a centrifugal fan of the steel plate or conoidal type, which forces it to the various parts of the building. Large fans running at low peripheral speeds and giving the highest efficiency, are used.



Motor-driven fan.



Fan with tight and loose pulleys for two different speeds.



Steam-engine driven fan.

The apparatus may be either belt, electric or steam driven, depending only upon which method is the most desirable and economical under the existing conditions at the place of installation. Generally speaking, operation of the system entirely independent of all other machinery is preferable so it may be run as desired. The system may then be operated in the early mornings to procure the desired atmospheric conditions before the other machinery is started.

Cooling. In summer when no heating of the building is required, the air should be introduced as cool and as near the point of saturation as possible so that it will absorb heat from the machinery, the sunlight, the people, etc. It must also be introduced in sufficient quantity to absorb this heat with the rise in temperature corresponding to the relative humidity desired; that

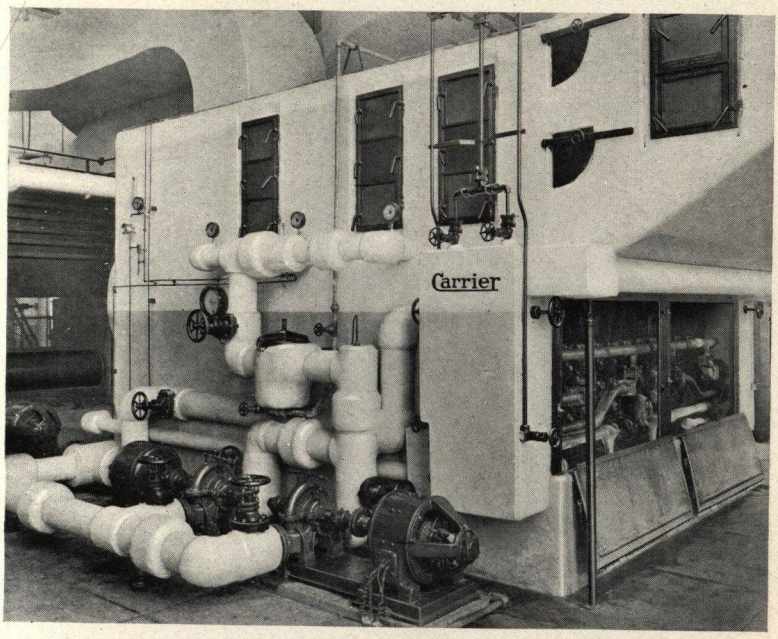
is, for 70 per cent it must rise 11¼ degrees.

Any successful dehumidifying system must keep this temperature balance, adding or absorbing heat as required.

While cooling is taking place, the greatest amount of air is required, which may for the time being make the resistance of the heater to the air supply objectionable. A by-pass with damper is therefore usually provided under the heater, and the by-pass damper is so controlled that it opens automatically when steam is shut off from the heater.

The Distributing System. The air circulation with a Carrier System is positive and complete throughout the building. The rooms are nothing more than enlargements of the ducts, with the air under slow motion, each cubic foot conveying to every nook and corner the same amount of water vapor. Maintaining a uniform relative humidity resolves itself therefore to the very simple problem of distributing the air in such a manner that a uniform temperature is procured.

The design of ducts depends entirely upon the nature of the installation, type of building and conditions to be maintained.



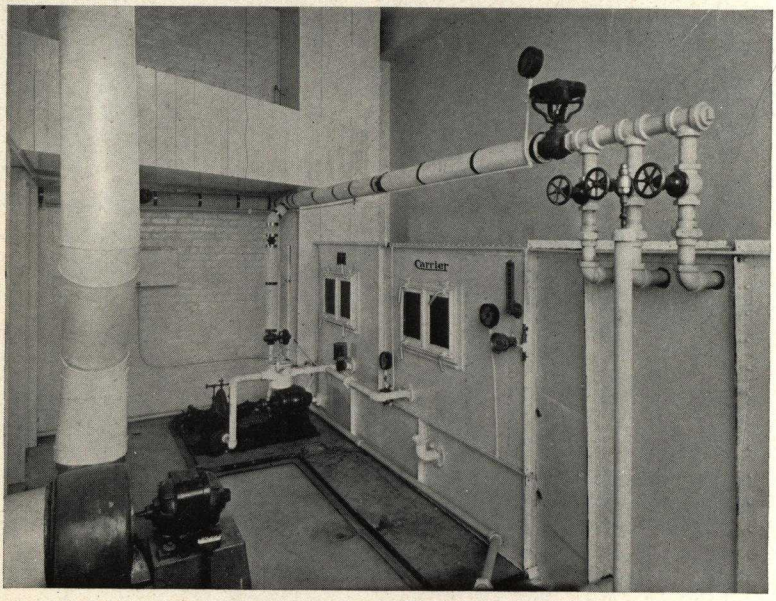
Carrier Dehumidifier with coil chamber door open for inspection. Note particularly the care we have taken with the piping details and insulation. All working parts are accessible, yet the loss of heat is reduced to a minimum.

The Carrier System of Dehumidification

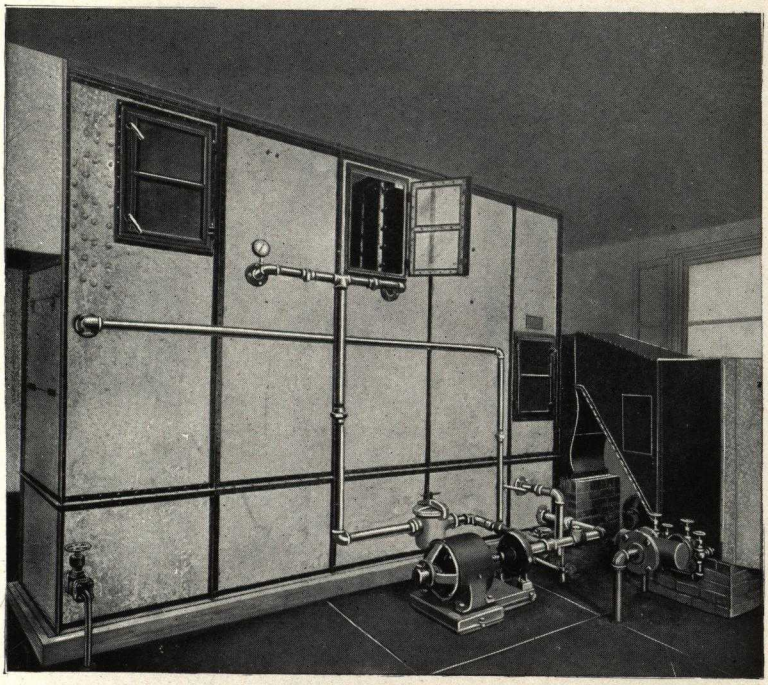
The experimental work necessary to enable spray type machines of high efficiency to be designed was conducted from 1906 to 1911. Upon the basis of this experimental work, Mr. W. H. Carrier and his engineering staff developed and standardized apparatus employing the spray principle. This Carrier System designed and patented by Mr. Carrier and put on the market in 1907, produces identically the same cooling and dehumidifying effects as obtained with cold brine coils, but with the advantages previously stated and further advantages of saving in size of ice machines, first cost, and attendance.

The Principle of Operation—The operation of the Carrier apparatus is very similar to that of the barometric condenser, in which large quantities of vapor with very small quantities of air are brought into contact with water of lower temperature and in sufficient quantities to absorb the heat of the vapor and air, thereby condensing the vapor. A vacuum pump is used to remove the air.

In the Carrier Dehumidifier, however, relatively large quan-



Carier Well-Water Type Dehumidifier in a Pennsylvania manufacturing plant.



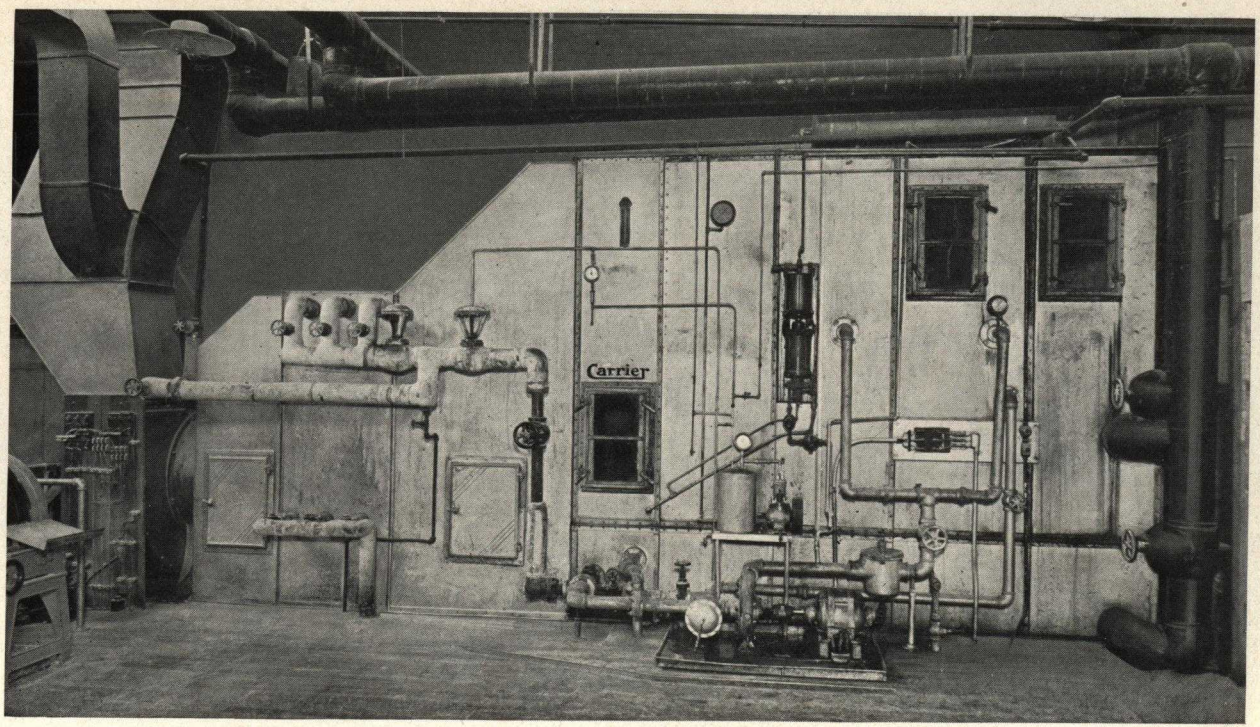
Carrier Dehumidifier of The Mirror Candy Co., New York. Used for drying hard candy.

tities of air usually at atmospheric pressure and with small amounts of water vapor are brought in contact with cool or cold water and the whole cooled to condense the vapor.

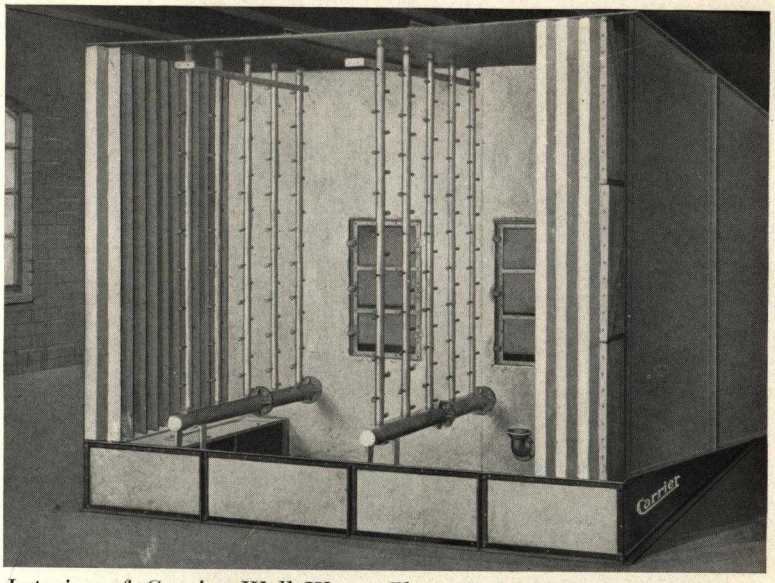
In all spray machines the air to be treated is passed through a chamber in which are uniformly distributed a number of nozzles, from which a very finely atomized spray of cold water or brine plays in direct contact with the air. At the exit the air comes in contact with a set of corrugated eliminator plates which remove all free moisture.

The amount of entrainment of particles of water is very small, and varies with the range in saturated temperature through which the air passes. Usually a rise of half a degree to one degree in the temperature of the air is sufficient to evaporate these small particles and make them disappear, and friction of air in the fan generally employed is enough to give this temperature rise.

The Carrier Well-Water Type Dehumidifier receives the supply of cold water from some exterior source. This water may be from a natural source such as a well, spring, river, etc., or



The Carrier Dehumidifier in the bakery of Gordon-Pagel Co., Detroit, which as the management tells us is a great improvement over the dehumidifying apparatus formerly used. *(See also page 4.)*



Interior of Carrier Well-Water Type Dehumidifier, showing air distributing plates, spray piping, eliminator baffles and settling tank.

it may be artificially cooled by refrigerating coils placed outside the dehumidifier.

The spray chamber is of sufficient length to accommodate two banks of spray nozzles. These nozzles discharge the cooling water in the direction opposite to that of the air current, thus producing a counter-current effect.

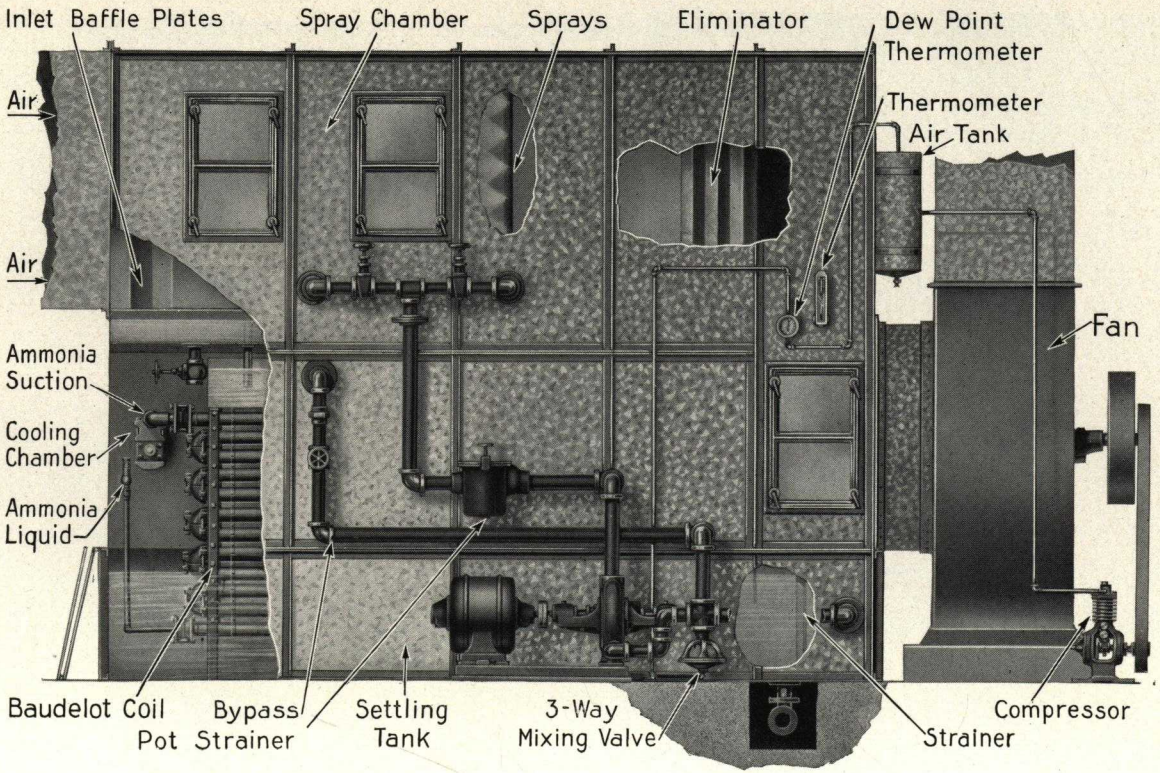
Overflowing of tank is prevented by large overflow connection capable of carrying away waste water as fast as it can accumulate.

A set of baffles in the air inlet end of the spray chamber assists in providing a uniform air velocity through the chamber, breaks up any eddy current which might otherwise be present, and prevents any of the water being discharged from the inlet end of the machine.

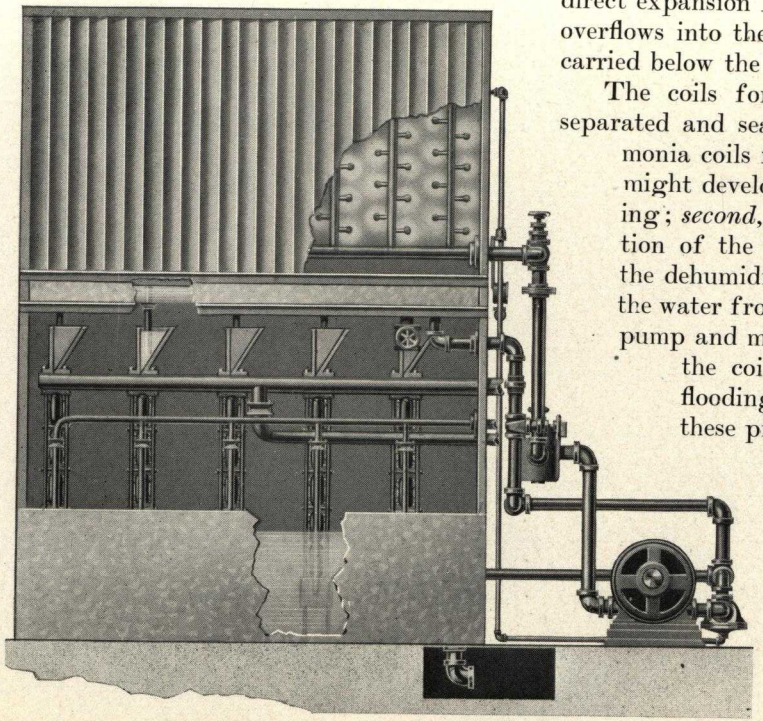
The eliminators at the air discharge end of the chamber effectively remove all spray and condensed water.

Where washing of the air is desirable in winter or when dehumidifying is not needed, a suction strainer is provided so that the water may be recirculated.

This type of machine is used occasionally even where artificial refrigeration is required to cool the water, the cooling being done in some other part of the plant and the cooled water being pumped to the dehumidifier.

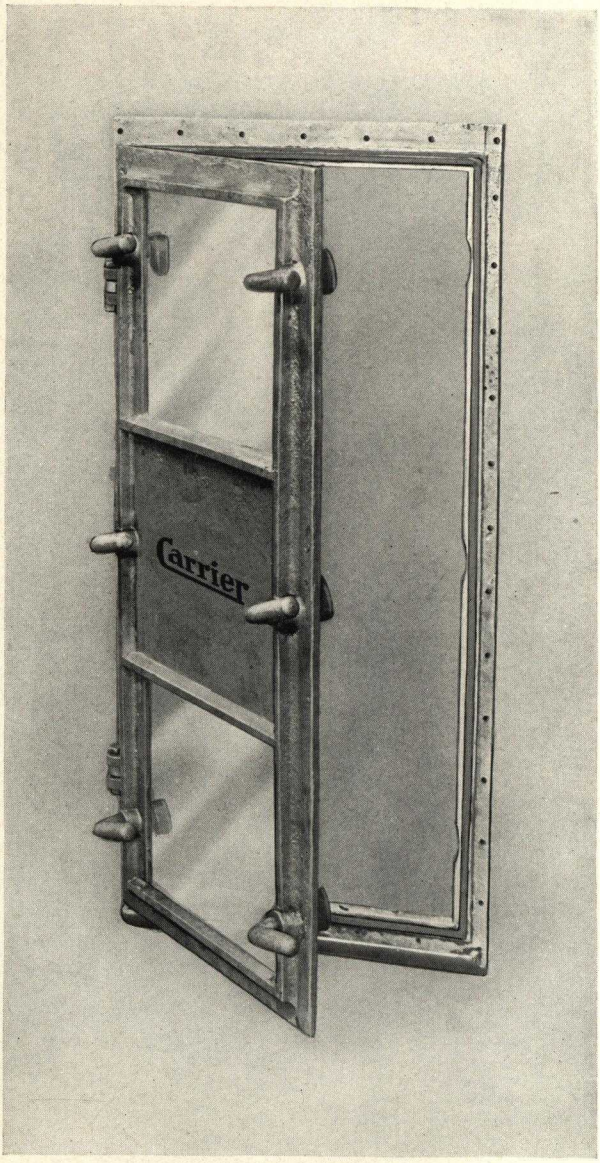

Inlet Baffle Plates
Spray Chamber
Sprays
Eliminator
Dew Point Thermometer
Air
Thermometer
Air Tank
Air
Fan
Ammonia Suction
Cooling Chamber
Ammonia Liquid
Baudelot Coil Pot
Bypass Strainer
Settling Tank
3-Way Mixing Valve
Strainer
Compressor

The Carrier Self-Contained Type Dehumidifier cools the water by refrigeration within the dehumidifier, is compact and highly efficient under a wide range of conditions.



The sprays are in the upper chamber and the lower contains direct expansion Baudelot coils. Water falling into the upper pan overflows into the flooding troughs below. The overflow pipes are carried below the water line in the troughs in order to seal them.

The coils for cooling the water or brine are in a chamber separated and sealed from the air chamber, *first*, to keep the ammonia coils from contact from the air, so that small leaks that might develop cannot contaminate the air supply to the building; *second*, for better regulation of the dew-point. Regulation of the amount of water vapor conveyed by air leaving the dehumidifier is accomplished by simply by-passing part of the water from upper tank direct to the centrifugal circulating pump and mixing it with cold water that has been passed over the coils. The water overflows through pipes into the flooding troughs in the coil chamber. The bottoms of these pipes extend into the water in the troughs thus providing the water seal. The water is distributed by the troughs very evenly over the Baudelot coils, to be cooled as it falls to the tank below, from which it is drawn by a centrifugal pump and returned to the sprays. If too much cooling is being done by-passing part of water from upper pan to the pump, and mixing with enough cooled water gives air leaving apparatus the required temperature.



The inspection door. Easy to operate, has large glass panels and remains watertight when closed.

Construction details of the Carrier Dehumidifier

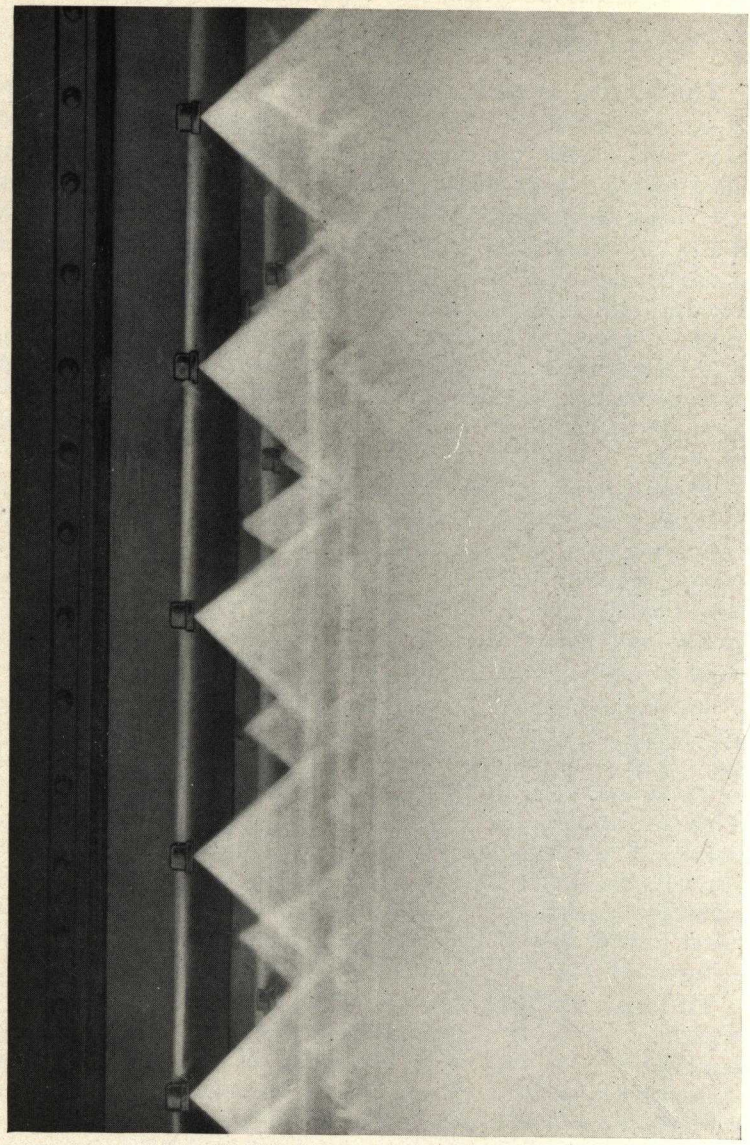
The Casing is made from sections of galvanized sheet iron rigidly supported on the outside by a galvanized angle-iron frame. The sides, top and tank are made separately, and are bolted together with rubber gaskets, joints thus providing for convenience in assembling and erecting, or for inspection and repairs. Additional bracing with angle iron is provided so that no sheet wider than three feet is unsupported. Each casing is provided with inspection doors as described in the next paragraph. The angle irons being galvanized and on the outside, away from all contact with water, are doubly protected against rusting, and rust of other parts is prevented by galvanizing surfaces, and soldering all seams, rivet heads and exposed edges of the sheets.

The Inspection Doors provided in both the sprays and coil chambers of all Carrier Dehumidifiers are of ample size to allow convenient access for inspection and cleaning. These doors carry at least two heavy 11-in. x 12½-in. glass panels on the larger sizes, and 14⅝-in. x 8¾-in. on the smaller humidifiers. Both the door and its frame are of cast iron, galvanized and sufficiently heavy to give strength and rigidity.

Our arrangement is most serviceable in that frequent opening and closing of the door will not impair the water and air tightness. The door presses against a solid rubber gasket set into the frame and is made tight by means of easily operated cams, which are provided on both sides, and pull solidly against the gasket. The hinges are so constructed that they do not interfere with the action of the cams. Leakage through the door is ordinarily impossible, but if a temporary leak does develop a gutter provided in the bottom part of the door frame catches the leakage and returns it to the tank.

The Carrier Spray Nozzle, though most effective, is very simple in construction. The water enters a small circular chamber tangentially, which gives it a whirling or centrifugal motion. The approach to the discharge opening is conical so the rotation, or whirling speed of the water, greatly increases on nearing the discharge. The effect of this arrangement is to give a powerful minutely divided or atomized spray, with an enormous amount of surface for washing and evaporation.

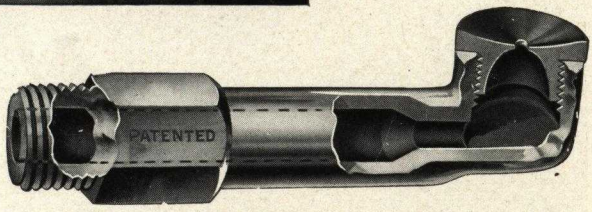
The construction of the nozzle is such as to make it very free from clogging with foreign material. The size of the orifice depends upon the requirements of the humidifier and is selected



Carrier spray nozzles in operation as photographed by flashlight through the inspection door. The liquid is so completely atomized that an almost unbelievable amount of surface is presented for the cooling of the air.

for each installation to give the required results. The smallest orifice used is 1/16 of an inch in diameter.

We do not use the so-called self-cleaning or self-flushing nozzles, as there is no more reason for letting dirt get into the spray piping system than there is in allowing obstructions to get into a water supply system and then hoping to clean them out by using flushing devices.



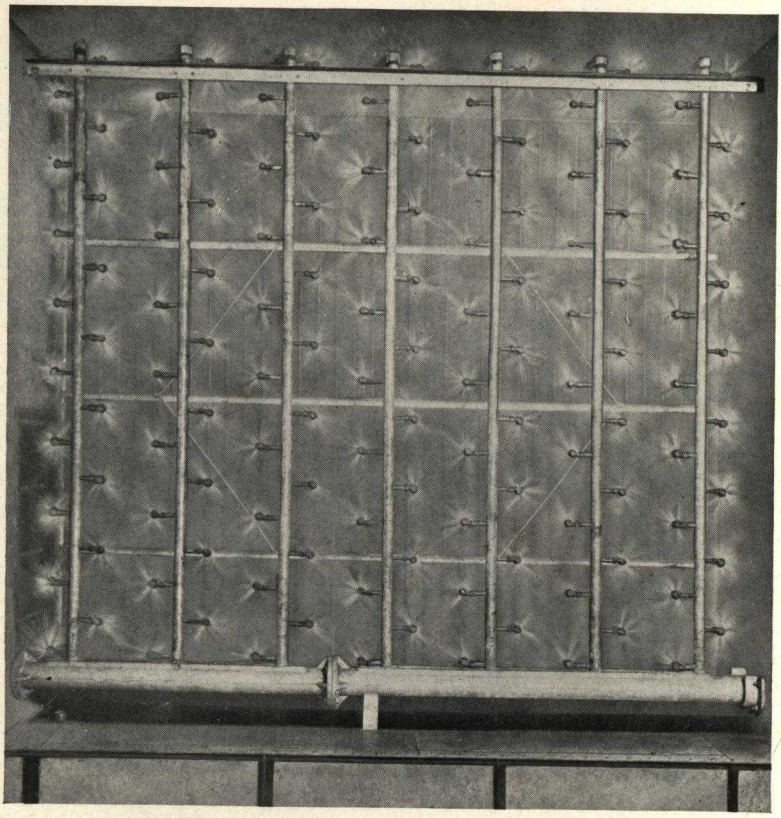
Typical Carrier spray nozzle and spray.

Our method is to thoroughly filter the water and effectively remove all dirt and foreign matter before it goes to the nozzles. See description of filters on pages 36, 37 and 40.

Although the discharge openings in the nozzles are much larger than those in general use, every precaution is taken to insure the removal of any lint or dirt from the water before it enters the spray piping.

The water pressure required varies with the type of dehumidifier and work to be performed, but never exceeds twenty-five pounds per square inch.

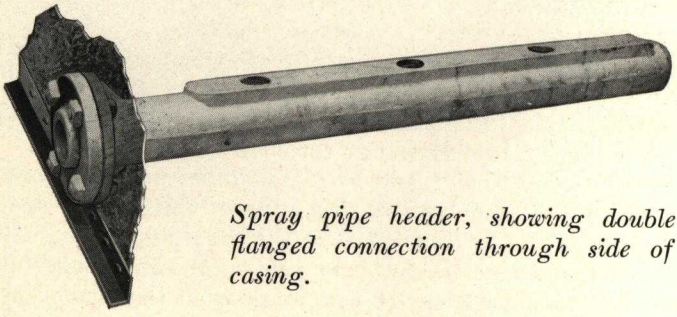
Spray Piping. The nozzles in all Carrier Dehumidifiers are placed in two or more banks and discharge in the opposite direction to the air flow, thus producing a counter-current effect which gives the highest heat exchange from the air to the water. The nozzles are attached by nipples to standpipes which in turn are mounted in cast iron headers that support them at the bottom, one header for each transverse set of standpipes. The standpipes are capped at the top and held in proper alignment by straps and bolts in connection with angle irons that extend across



Sprays in a Carrier Dehumidifier. Note the distribution.

the spray chamber and are held to its sides by rivets and special fittings.

All iron pipes, fittings and parts used in the spray piping system are heavily galvanized and noncorrosive. Small valves



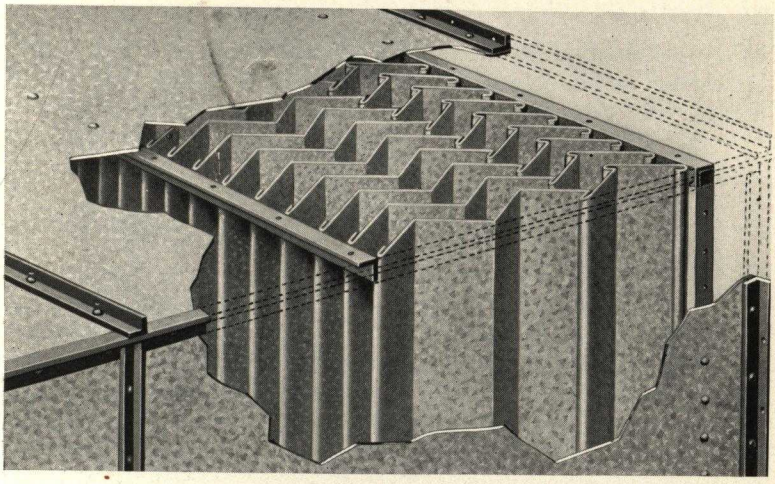
Spray pipe header, showing double flanged connection through side of casing.

are entirely of brass, and large valves have galvanized iron bodies, brass fitted.

Wherever a water pipe extends through a side of the dehumidifier, neat finish is given to the apparatus, and leakage prevented by using at each of these points two companion flanges with pure rubber gaskets placed on each side of the casing.

Air Distributing Baffle. Equalized air velocity and uniform air distribution through the spray chamber are quite as necessary as the thorough distribution and atomizing of the water. A set of baffle plates is therefore placed across the air inlet. These are made of the same material as the eliminators and are braced with angles bolted to the casing.

Since the water from the nozzles is discharged in the opposite direction to the air flow, these inlet baffle plates also prevent the spray from forcing its way out of the end of the humidifier.

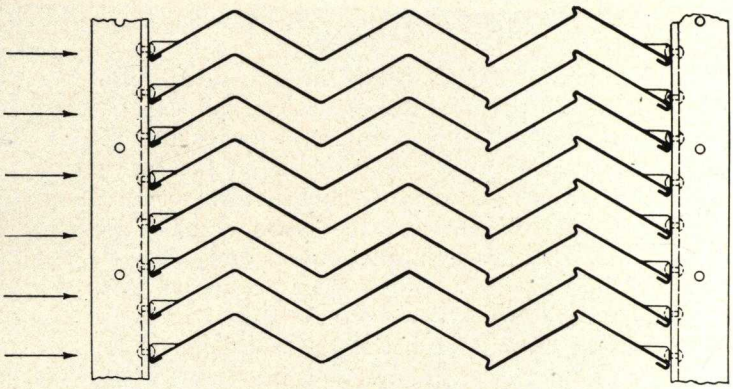


Showing eliminator construction in the Carrier Dehumidifier.

Eliminator Design and Construction involves two prime considerations: (1) Removal of the small particles of water which would be carried by the air currents, and (2) Doing this with minimum resistance to passage of the air.

Provision for elimination demands an abrupt change in the direction of the air current in order to throw the entrained moisture against the eliminator plates. The wider the space between the plates, the greater the necessary angle through which the air is baffled.

For this reason an angle of deflection of the air of 60 degrees with the spacing of plates only 1⅛ inches apart eliminates more



Showing relative spacing, proportions and angle of deflection of the eliminators in a Carrier Dehumidifier.

effectively than the 90 degree angle with spacing of 4 to 6 inches. As the air passes between these plates, and is baffled from one to another, the free water is caught and drains to tank below.

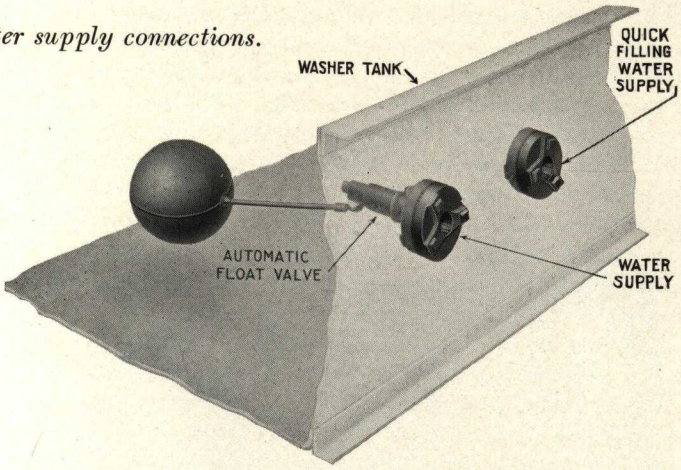
The resistance in an eliminator depends more upon the angle through which the air is baffled, and the eddy currents set up thereby, than upon the surface friction. In fact the resistance of the same amount of parallel surface is so small that it would be very difficult to measure.

The eliminators in Carrier Dehumidifiers are made up of a series of corrugated plates spaced and set in a *vertical* position on 1⅛ inch centers across the discharge end of the spray chamber. Each eliminator is made of a single sheet so stamped as to form six corrugations, with three of the corrugations having stamped lips projecting. The resistance of the complete eliminator at rated capacities, is less than .25 inch water gauge.

The plates are held together with angles at the top and bottom, and at intervals through the height to keep them evenly spaced. All the eliminators are galvanized iron or copper so that there is no chance of corrosion.

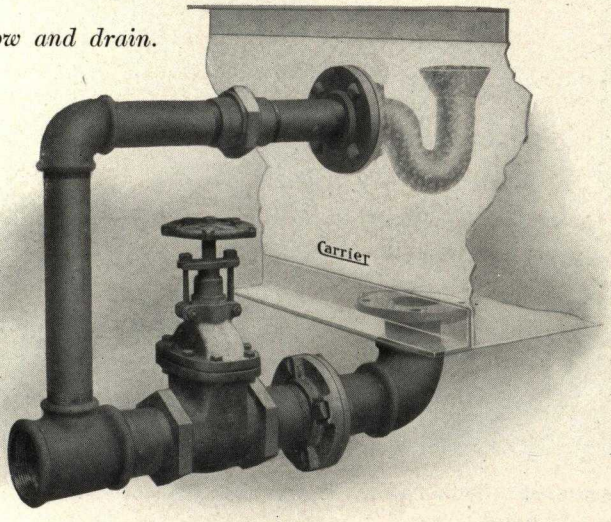
Water Supply is received and the desirable water level is maintained by a ¾-in. float valve which connects with the service mains through gasketed companion flanges set in the side of the washer tank. An additional set of companion flanges of the same size, and installed aside of those for the water supply connection may also be connected to the service main through a globe valve to provide a quick water supply for flushing and cleaning out the tank. A hose connection in the service main is also a convenient help for washing out the tank.

Water supply connections.



Overflow and Drain. A flanged connection flush with the bottom of tank and bolted to it and having elbow and brass gate valve is provided for draining off the water and accumulated dirt. An independent bell-mouth cast iron overflow with water seal is arranged in the tank to provide for draining off any surplus water and to prevent any chance of flooding the tank. The overflow and drain are connected outside the tank to a tee from which connection to sewer is made. The overflow is a special galvanized casting with flange bolted to tank. Piping and fittings included with drain and overflow are indicated in the photo.

Overflow and drain.



The Settling Tank, extending under the entire dehumidifier and eliminator, is enclosed in a strong galvanized angle-iron frame, which also serves as a very rigid and substantial supporting base for the rest of the humidifier. The tank, composed of heavily galvanized sheet metal with riveted seams, is firmly riveted to the frame and is made impervious to rust by soldering all rivet heads and seams.

The tank is provided with:

A flanged outlet for connection to the pump suction line.

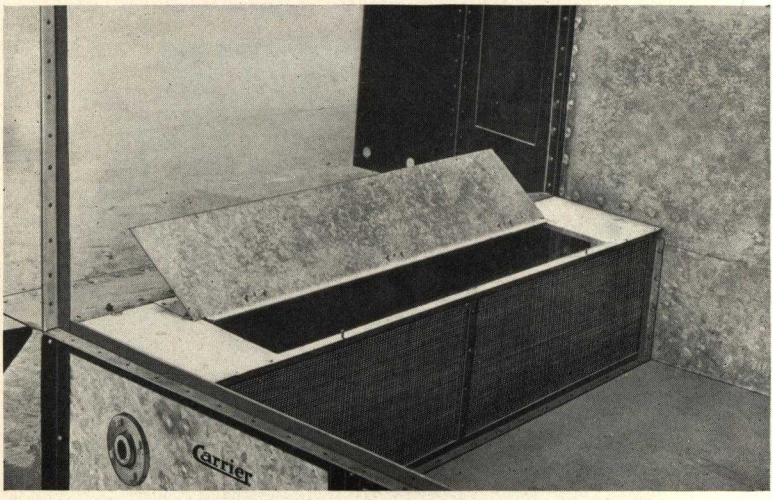
An automatic float valve which controls the water supply and maintains a constant water level in the tank.

An overflow, with U trap, which connects to the sewer and which is a guarantee against flooding the tank.

A drain valve arranged under bottom of tank, connects to the sewer, so that all water may be drawn off for cleaning.

Suction Strainer. The settling tank is divided into two compartments by a wire cloth strainer, through which the water passes before entering the suction of the pump. This strainer offers a surface of more than one square foot for each foot in width of the tank, and as the area of the strainer is many times that of the suction pipe, thorough filtration of the water at very low velocity is provided.

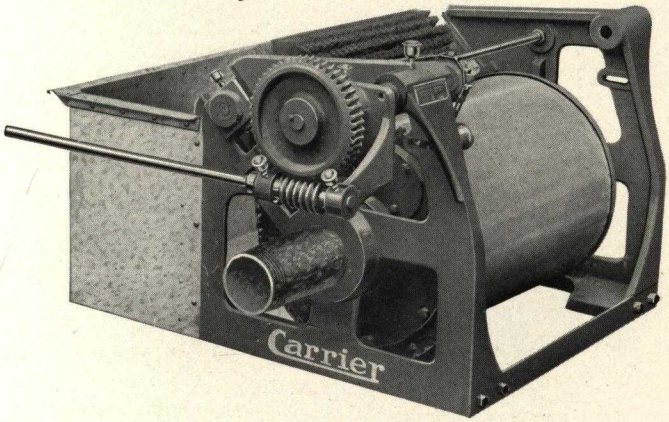
A cover over the top of the compartment formed between the strainer and the end of the tank to which the suction of the pump is connected, prevents dirt from falling into the filtered



The suction strainer, showing pump suction connection in the lower left-hand corner.

water as air passes over it. The swinging lid in this cover is easily opened to allow for cleaning the strainer.

Believing that elimination of dirt from the water before it enters the spray system is far better than attempting to remove dirt that has once entered, we make the strainer of No. 12 mesh copper gauge, which has interstices much smaller than the openings (3/32-in. diameter) in the spray nozzles. No clogging of the nozzles is therefore possible, and flushing of the piping and nozzles is never necessary.



The Carrier self-cleaning rotary strainer.

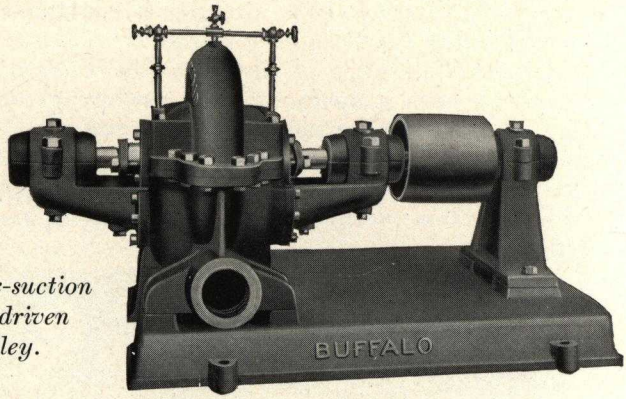
The Carrier Self-Cleaning Rotary Strainer is recommended for installations where excessive dirt, lint, fibrous material or other solid matter must be removed from the air.

This strainer has a rotary cylindrical screen of fine mesh copper wire cloth that easily retards any dirt particles large enough to interfere with action of the spray nozzles.

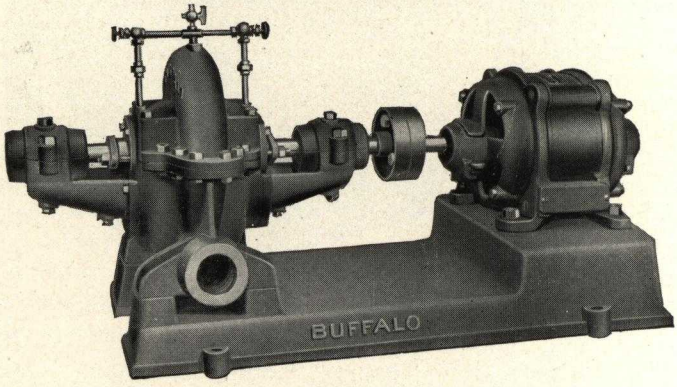
The revolving screen is fitted with a stiff round brush which also revolves and constantly sweeps the strainer clean of all dirt, which it carries to a small tank where the dirt is deposited so that it cannot again mix with the water. Cleaning of this tank, except under unusually severe conditions, takes not more than fifteen minutes and usually is necessary not oftener than once a week.

The suction line to the pump runs through one of the trunnions upon which the strainer revolves. A one-fourth horse power motor, placed outside the tank, will drive one of the largest size strainers.

The combination of a self-cleaning strainer and large orifices in the nozzles is of great benefit in reducing the amount of attention required.



Double-suction pump driven by pulley.



Double-suction pump driven by direct connected motor.

Pump. Years of practical operation and trials of many types have led us to adopt a special design, double-suction centrifugal pump with enclosed impeller. Double-suction pumps cost more than single-suction pumps but are more efficient and better in every way; hence their exclusive use with Carrier Dehumidifiers. The shell is split horizontally to allow of easy internal inspection without disturbance of pipe connections. The impeller is made in two parts, split at right angles to the length of the shaft, which allows the water passages to be finished and the parts afterward riveted together. Two large bearings, one on each side permit impeller to be kept exactly in correct position, and maintain the very small clearances essential to high efficiency.

The pump is driven preferably by a directly connected electric motor, but may be driven by steam engine or turbine, gas engine, belt or other desirable power.

The pressure required for complete atomizing and distribution of the water is from 25 to 30 pounds per square inch.

The Carrier Dew-Point Control

The Carrier method of automatically regulating the amount of vapor conveyed by the air is based upon the control of the dew-point or saturated temperature of the air leaving the dehumidifier.

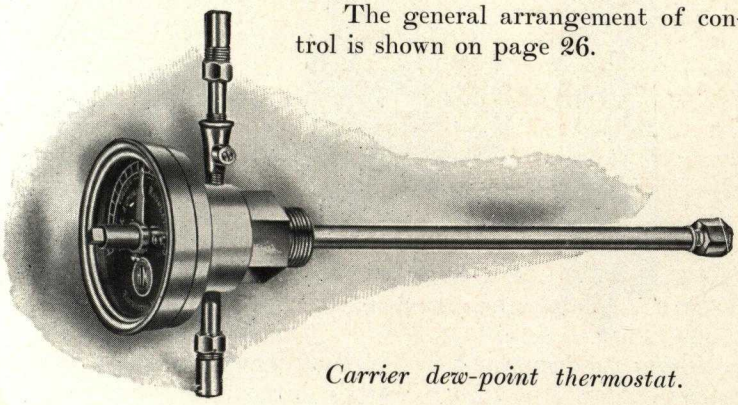
As the air is cooled in the dehumidifier it is brought to saturation and a further cooling removes a portion of the vapor. As the air passes through the eliminators all surplus water or entrainment is removed, so the air leaves completely saturated, cool and clean. Therefore by regulating the temperature of the air leaving the dehumidifier the amount of vapor is fixed.

By mixing warm air returned from the building with fresh outside air and by mixing warm water returned from the dehumidifier with cold water supplied to the sprays in proper proportions and varing these proportions as necessary, the dew -point may be maintained constant under all varying weather conditions.

This is accomplished by simple, dependable, extremely accurate, scientifically correct and practical devices that have many advantages over other methods that have been proposed.

The whole combination is extremely sensitive, as any variation in the air temperature passing over the stem of the graduated thermostat produces a change in the air pressure on the diaphragm air motor or on the diaphragm mixing water valve causing them to partially open or close, thereby producing a new temperature. Within a few seconds the water of the changed temperature is sprayed into the air and removes from it more or less heat in accordance with the requirements of the thermostat. This changed air temperature in about one second passes over the stem of the thermostat imparting the temperature change to it, thereby completing the cycle. This system while sensitive is not frail or delicate, but well able to meet any and all variations between existing limits without readjustment.

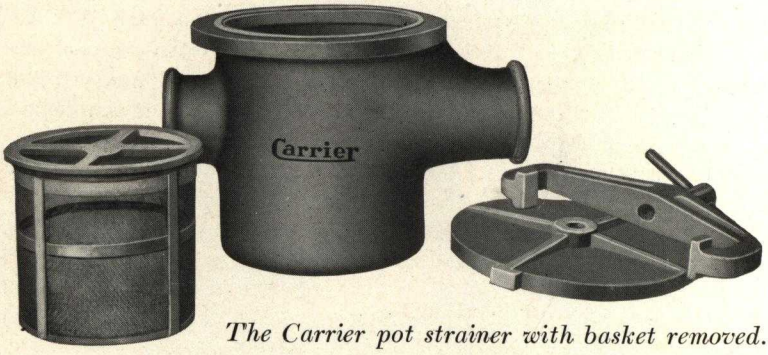
The general arrangement of control is shown on page 26.



Carrier dew-point thermostat.

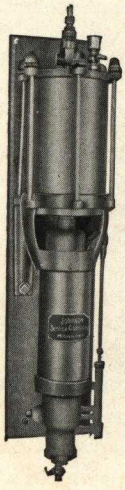
The stem of the graduated thermostat is placed in the passage just beyond the eliminators, so that it is exposed to the temperature of the air leaving the dehumidifier. Any change in this temperature causes expansion or contraction within the thermostat and the influence of this expansion or contraction upon a system of compressed-air-operated valves and dampers changes the degree of heat in the spray water to bring the temperature back to the desired normal for which the thermostat is set.

The Pot Strainer used in the discharge line of the pump is for the purpose of catching any scale or dirt which may be brought from the steam lines into the ejector. The suction



The Carrier pot strainer with basket removed.

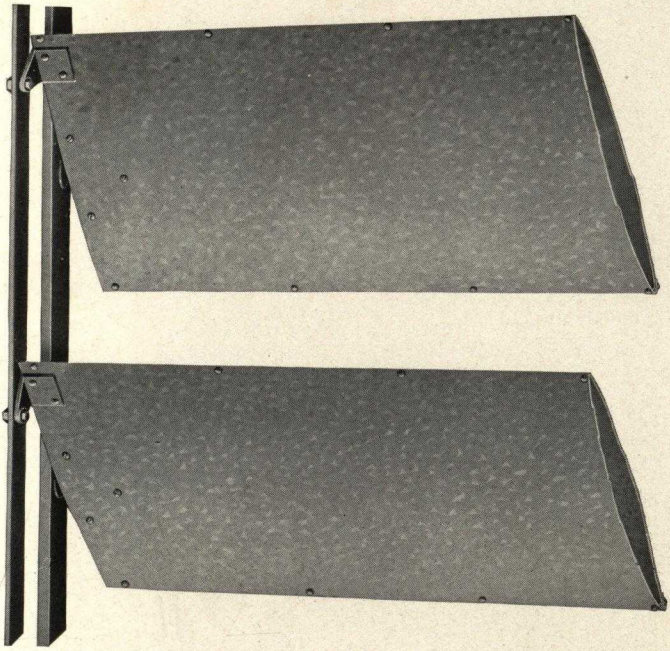
strainer in the settling tank removes all dirt from the spray water, but the pot strainer is an additional insurance against stoppage of the spray nozzles.



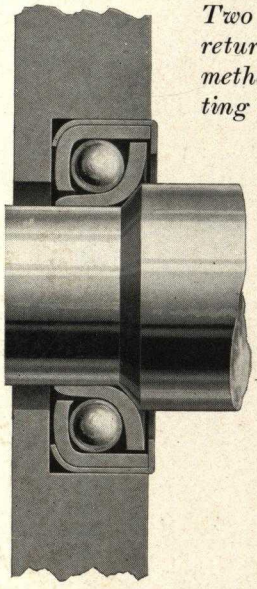
Hydraulic-driven air compressor.

Pulley-driven air-cooled air compressor.

The Compressed Air System. Air pressure at about 15 pounds per square inch for diaphragm control is maintained in a storage tank, served by an air compressor. This compressor in large installations is belt-driven from the same motor that drives the fan as shown on page 26 or the one that drives the circulating pump as shown on page 16, or in small installations may be



Two shutters of a typical Carrier fresh and return air damper, showing construction and method of mounting and attaching to operating mechanism.



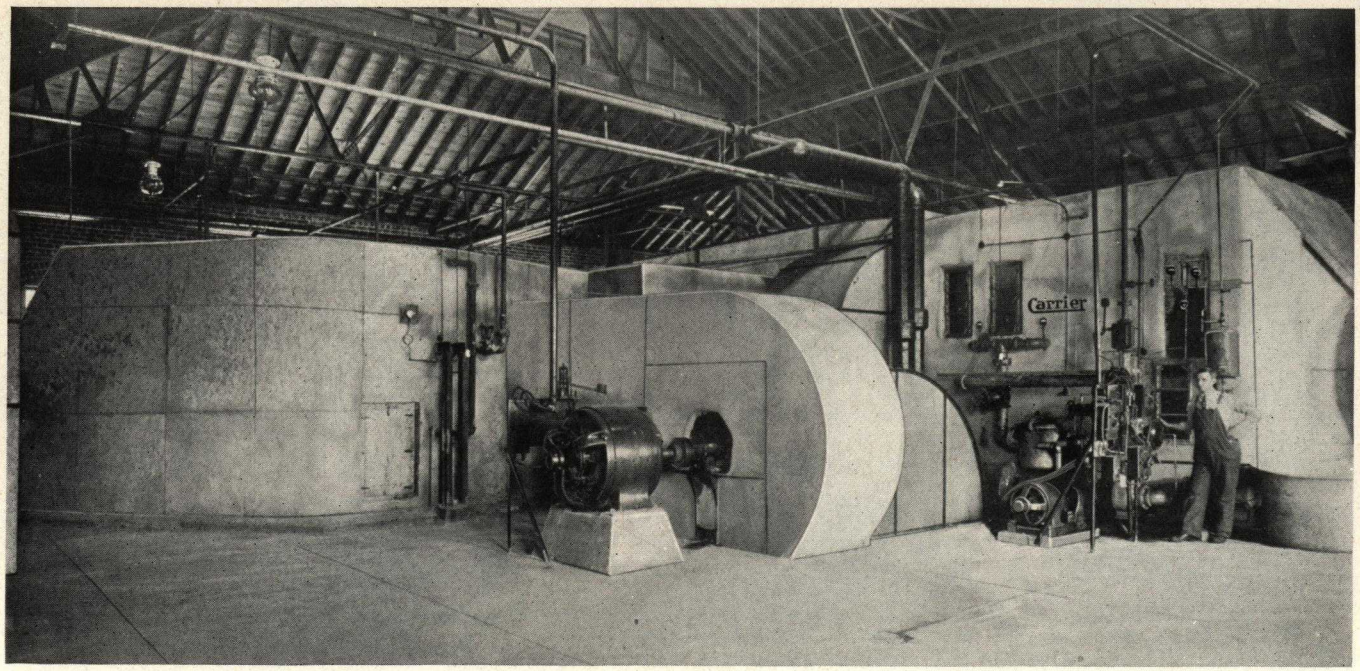
Showing method of mounting shutters on ball bearings for easy operation.

hydraulically driven by spray water pressure, and the water exhausted into the dehumidifier tank.

Fresh and Return Air Dampers. Each metal louver damper is made from a single sheet of galvanized steel formed elliptical and braced internally with castings which carry the trunnions for the bearings. These dampers are exceeding rigid and strong.

The use of ball bearings carried in a heavy bar support insures easy operation which is quite essential for accurate automatic control.

The louvers are operated simultaneously from one point by means of strong and easily operated links.

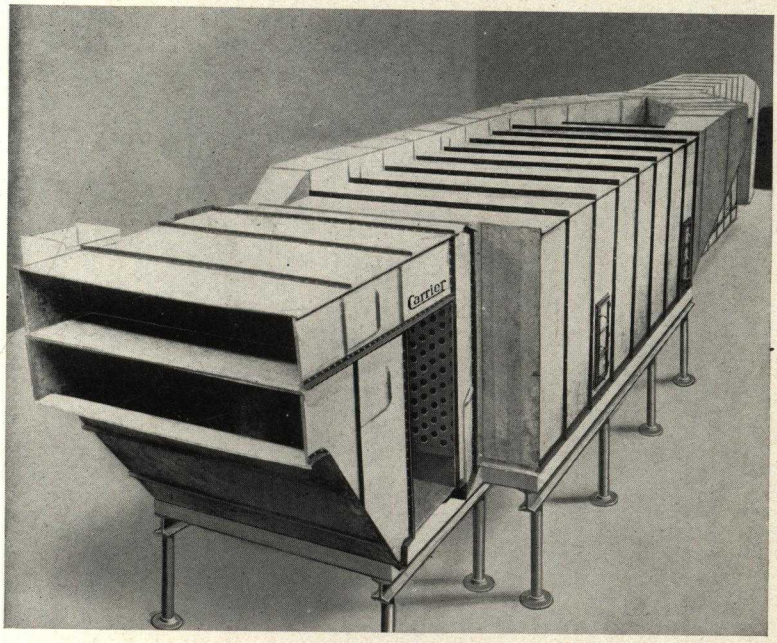


Carrier Dehumidifier and Interchanger in the Indianapolis plant of Eli Lilly & Co., Manufacturing Chemists. The maintenance costs have been very small, the temperature and humidity regulation close and the eliminators in the humidifier remove the mechanically suspended water particles from the air.

The Carrier Interchanger for economy in producing warm dehumidified air for drying

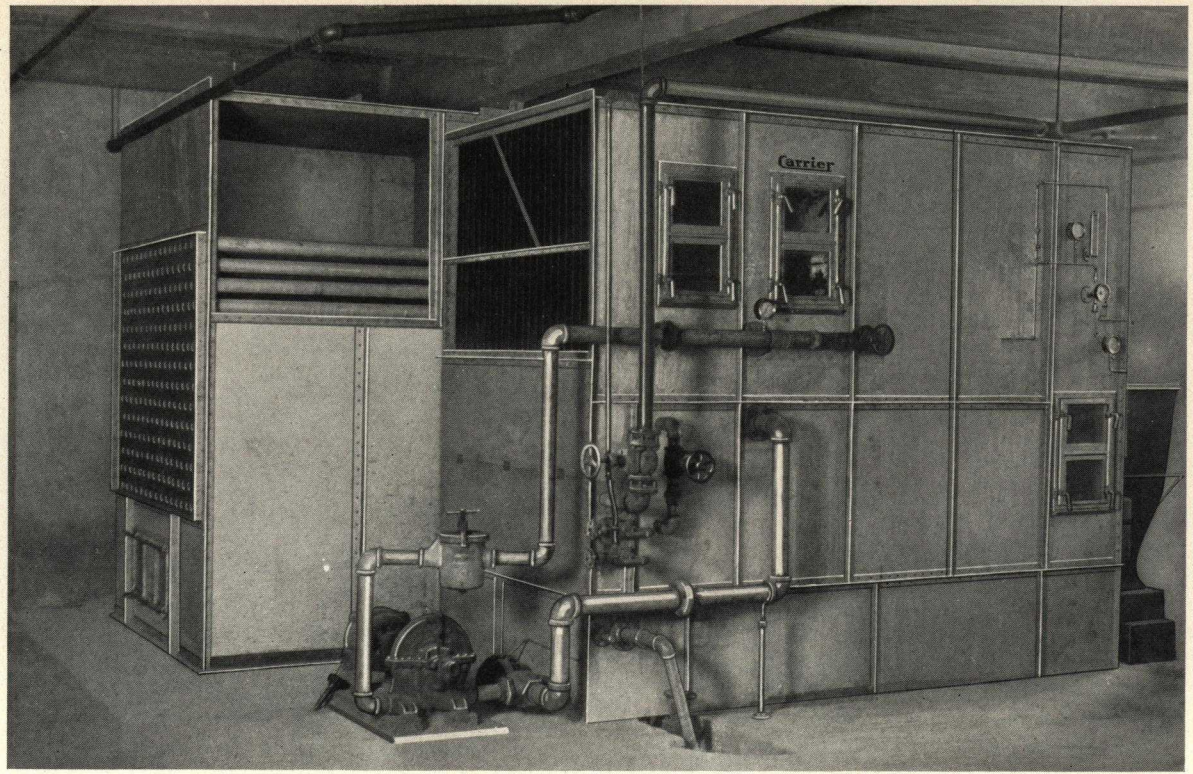
Where it is desired to heat the air after the moisture content has been reduced to the desired amount, the use of a Carrier heat interchanger will effect considerable economy in operation.

This is a very simple device, consisting of a number of tubes, over which the incoming warm air passes on its way to the final

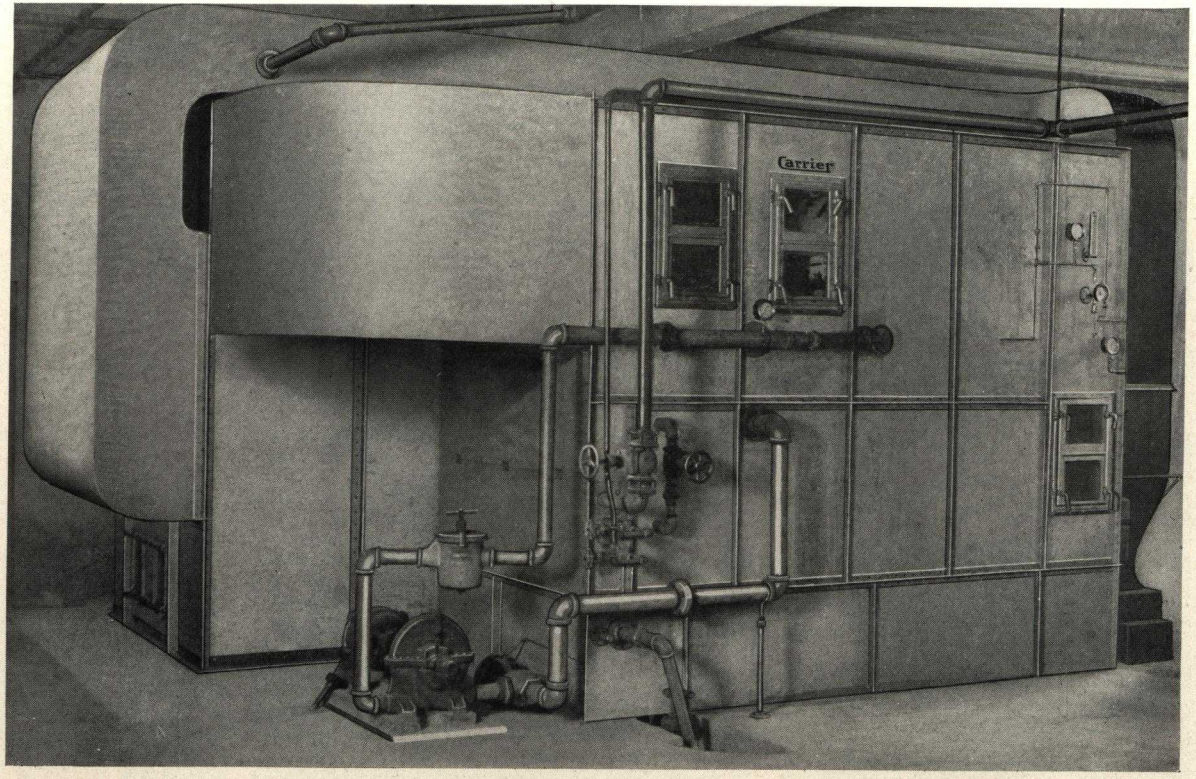


Interchanger applied to Carrier Dehumidifier. Under maximum conditions this plant operates at about one hundred and ten tons capacity. Thirty-two tons is done by well water, which is procured at 56 degrees Fahr., thirty tons is done by the interchanger, and the remaining forty-eight tons by refrigeration. The artificially cooled water enters the dehumidifiers at 33 degrees Fahr. and the compressors run with a suction pressure varying from thirty-five to forty pounds.

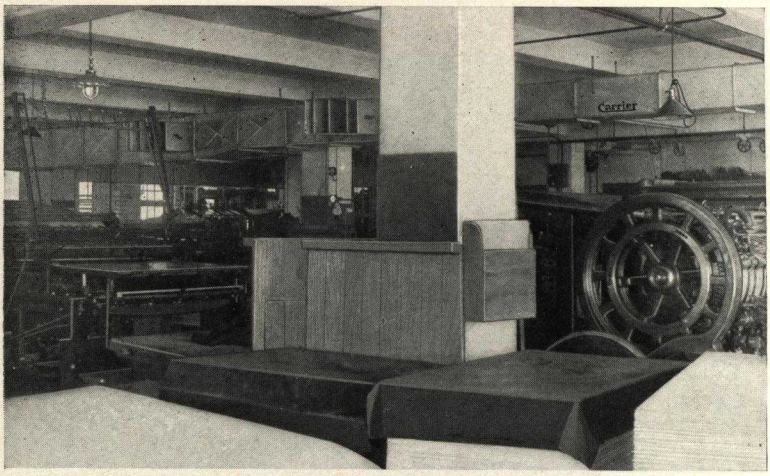
The dew-point, or the temperature at which the air leaves the final dehumidifier, is automatically controlled by by-passing a portion of the water around the Baudelot coils and mixing it with water which has been cooled, thus procuring the proper temperature for the work required.

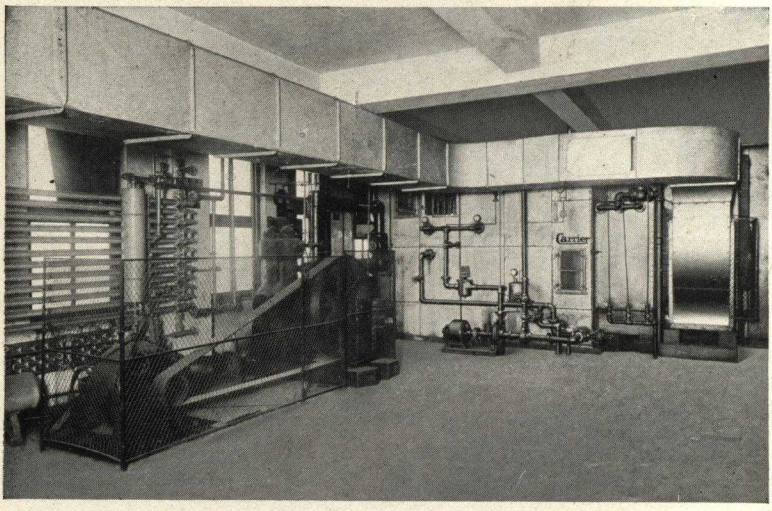


Typical Carrier Dehumidifier partially installed and showing the end of the interchanger before connections were made to the dehumidifier.

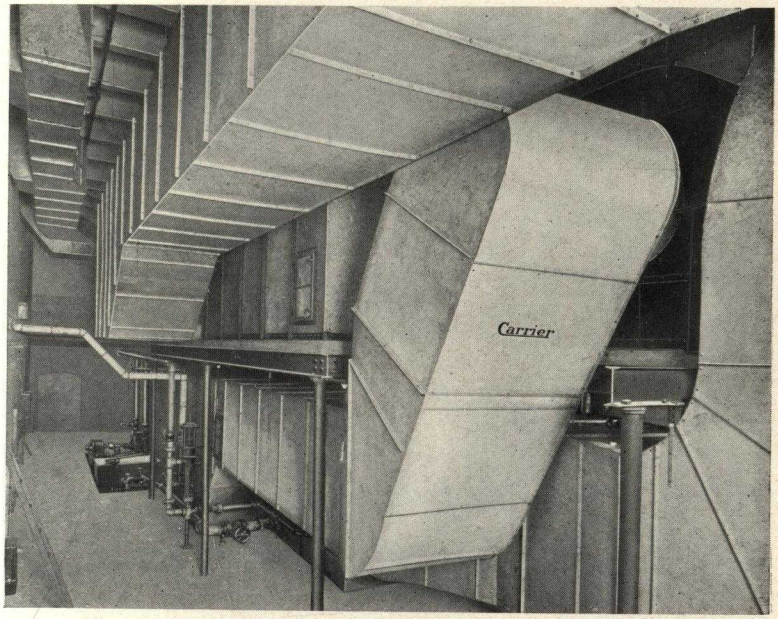


Typical Carrier Dehumidifier completely installed and ready for service.





Press room and Carrier Dehumidifying Plant of the Dittman Color Print Co., New York. Variation in the degree of moisture in a press room causes alternate shrinking and stretching of paper stock which interferes with accurate register in color printing. The atmospheric condition is also responsible for the static electricity that makes the sheets of paper stick together and hard to handle. Mr. S. E. Dittman, President of the above company tells us that through having this Carrier apparatus his firm was able to run day and night shifts without cessation and take business away from competition at a time when color printing plants without air conditioning apparatus could not run at all.



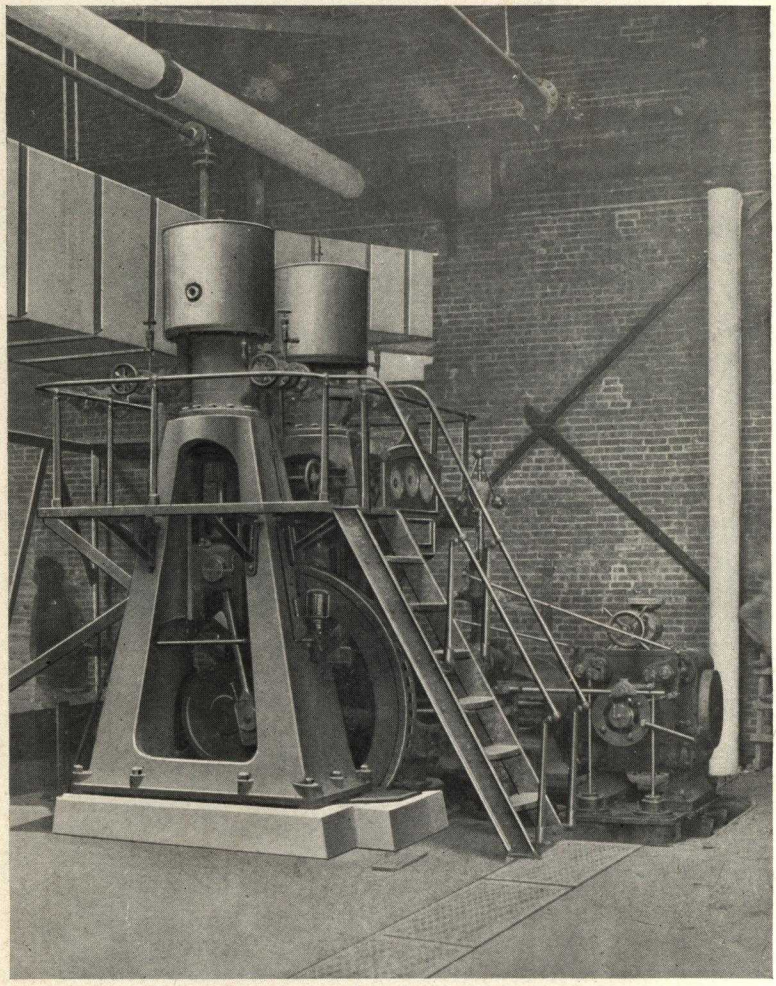
Carrier Air Conditioning Equipment installed in a film base plant.. The interchanger, well water and refrigerated water dehumidifier with position of the automatic control are shown.

dehumidifier, while the dehumidified air leaving the dehumidifier passes through the tubes in the opposite direction. The resulting interchange of heat from the warm air to the cold air serves the double purpose of cooling the incoming air and heating the air which has been dehumidified. The interchangers take up considerable room, but can be made to do 25 per cent to 35 per cent of the total work, often effecting a considerable saving in first cost, as well as reduction of about 35 per cent refrigeration.

The only added cost in operation for the use of the interchanger is the power required to overcome the friction of the air over and through the tubes. This is only a very small per cent of the power saved in pumping cold well water or in providing refrigeration that would otherwise be required.

This interchanger is manufactured exclusively by us under the Lyle patents. It can be installed within reasonable limits of first cost, and is applicable to both well water and self-contained types of dehumidifiers.

Water Cooling vs. Brine Cooling. The practical limit to which air can be cooled with spray dehumidifying apparatus when using water is between 38 degrees and 40 degrees Fahr. If



One of three vertical single-acting ammonia compressors with horizontal Corliss engine installed by us in the plant of British Munitions, Ltd., Montreal.

lower temperatures are required it is necessary to use brine instead of water. Where the air treated is to be breathed, or brought in contact with food products, a sodium chloride solution is preferable to a calcium chloride solution, as, with the use of the latter, an objectionable odor is usually present. In the dehumidifying or drying of air for blast furnace work, however, calcium brine seems to give very satisfactory results.

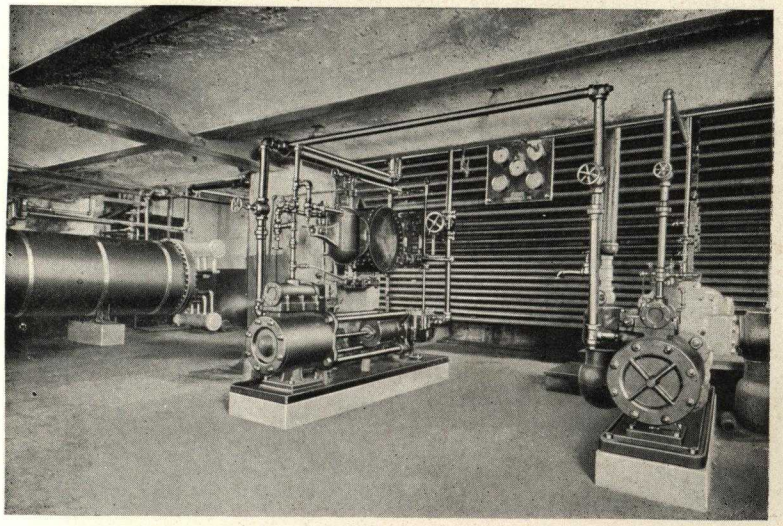
The brine is kept at a constant specific gravity by passing a small portion of it continuously through an evaporator or vacuum pan similar to those used in the manufacture of sugar, an open evaporator being used where live steam is employed for the concentration, and a vacuum pan where exhaust steam is used. By maintaining a constant vacuum, and thermostatically regulating the temperature of boiling, the strength of the solution can be uniformly maintained.

Cooling of the Spray. The type of cooler selected depends upon the liquid used for spray, the question of continued uninterrupted operation being more important than efficiency.

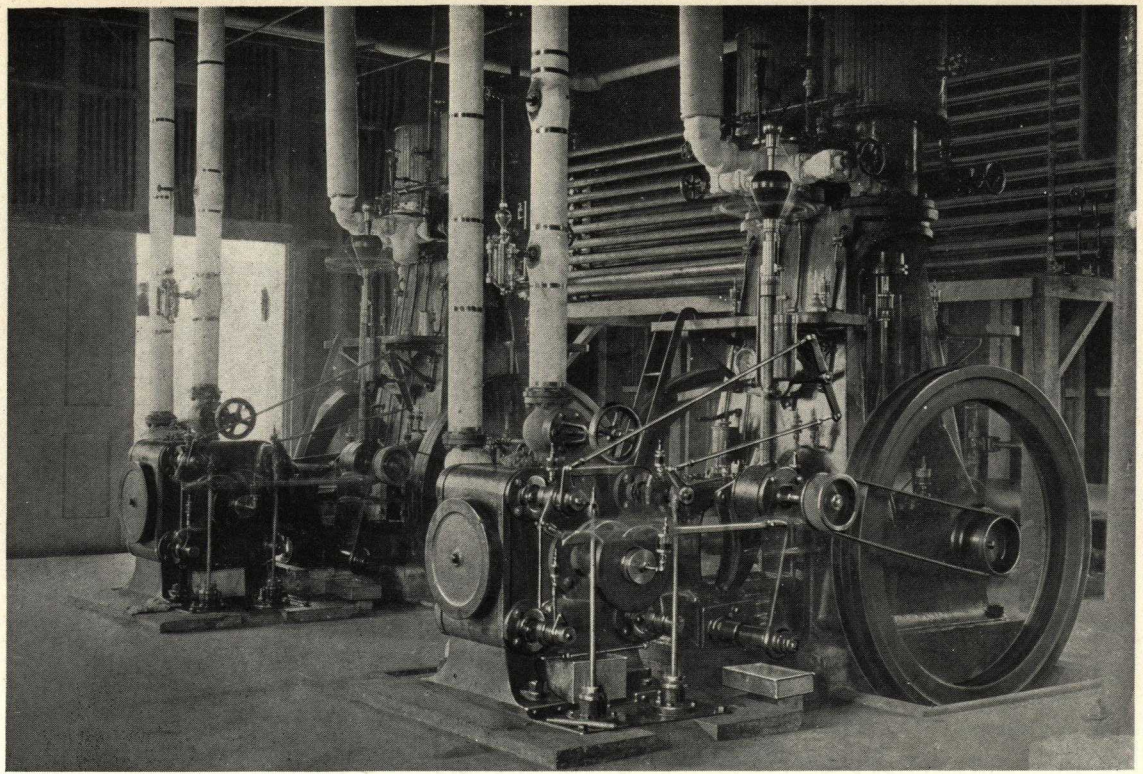
Double pipe or the shell and tube type of brine coolers are undoubtedly the best for use where the brine is of sufficient density to insure against freezing.

Double pipe coils, in which the brine circulates in the inside coil and the ammonia in the annular space between the pipes, being made in units are the more flexible. The liquid ammonia enters at the bottom and the gas passes off at the top, while the brine enters at the top and leaves at the bottom, thus producing a perfect counter-current effect with a high velocity.

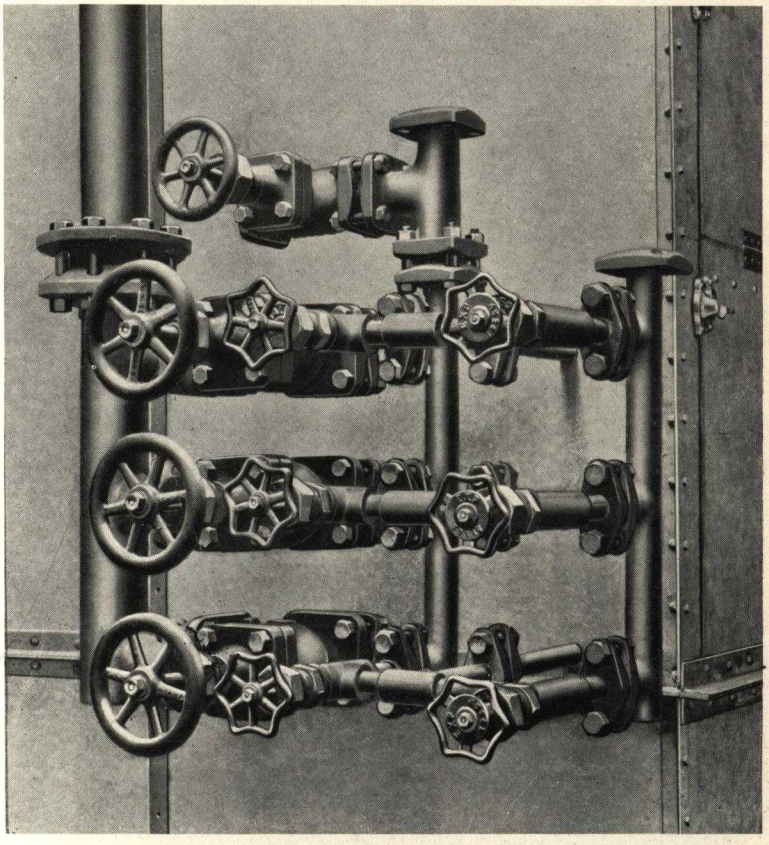
Carrier Baudelot Coils. The cooling of water for the spray cannot be accomplished in a double pipe coil without danger of carelessness or neglect resulting in freezing within the coils.



Absorption refrigerating machine of the type furnished by us to the Masonic Temple, Philadelphia. Ballinger & Perrot, Architects.



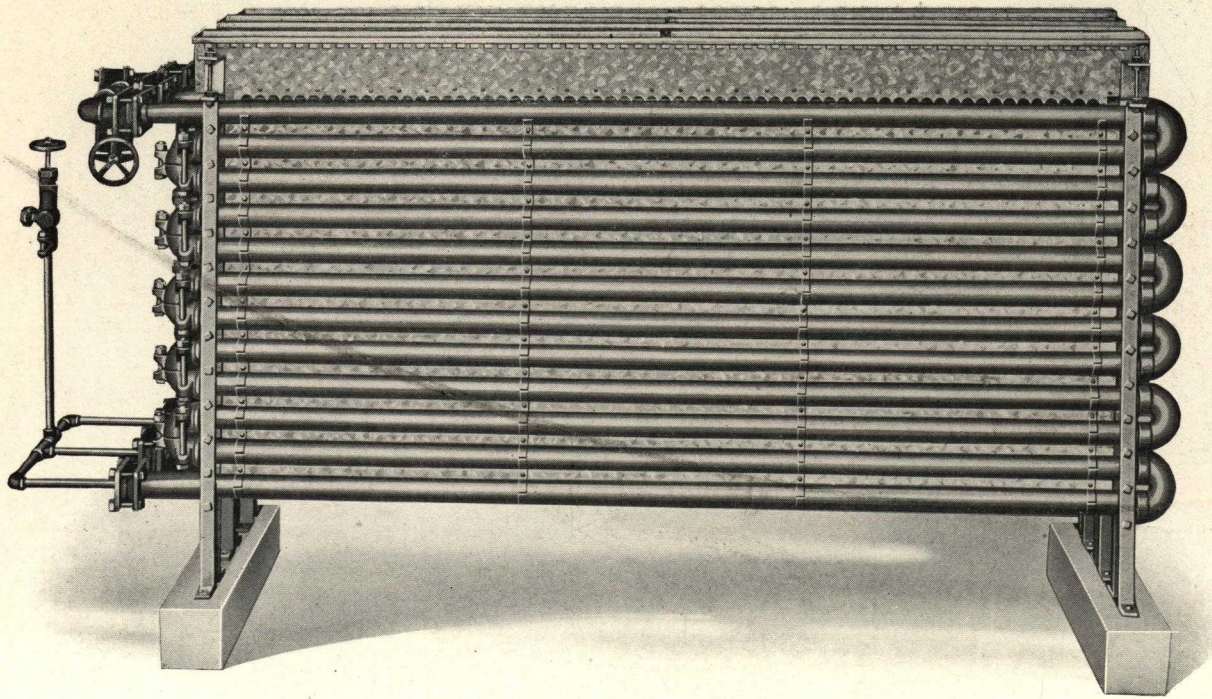
Two 45 ton single-column vertical single-acting steam-driven ammonia compressors and coils, which are part of the Carrier Dehumidifying Outfit installed in the power house of a fuse plant.



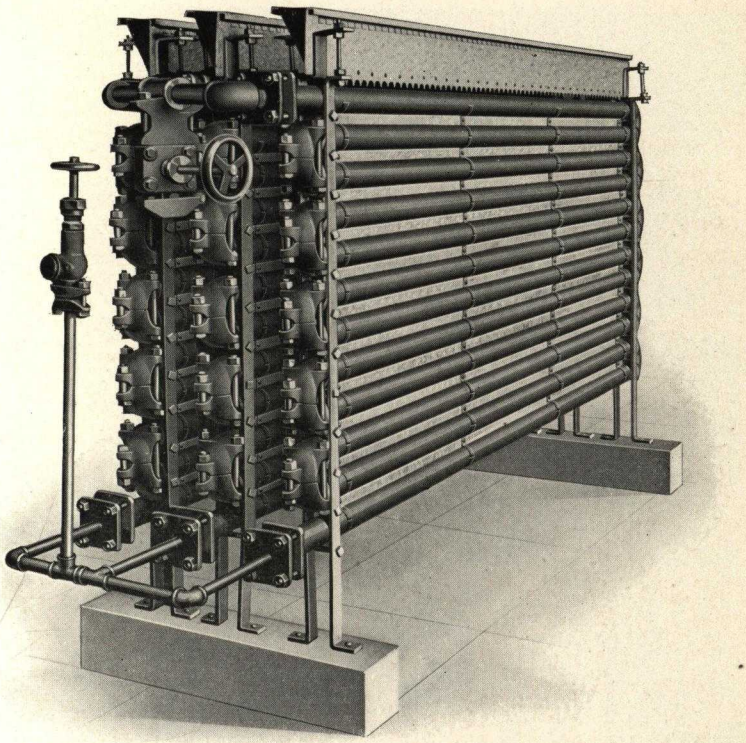
Suction, liquid and pump-out valves for Baudelot Coils. Located outside the dehumidifier.

Baudelot coils, made of extra heavy steel pipe galvanized on the outside, are considered best for water cooling. The efficiency of the surface is much greater than with submerged coils, as the rapid flow of water over the pipes greatly increases the rate of heat transmission. The flooding troughs are galvanized, provided with adjustable wires, and supported by brass fittings with iron adjusting nuts. Galvanized splash strips between the pipes of each coil guide the water evenly from one pipe down to the next lower. This combination produces very uniform distribution of the water over the surface and affords the maximum efficiency procurable without danger of freezing. With these coils, cooling of the water down to 32° without freezing is entirely practical because of the rapid motion of the water.

The coils are located within the self-contained dehumidifier or



Typical Baudelot Coil Unit from a Carrier Dehumidifier.



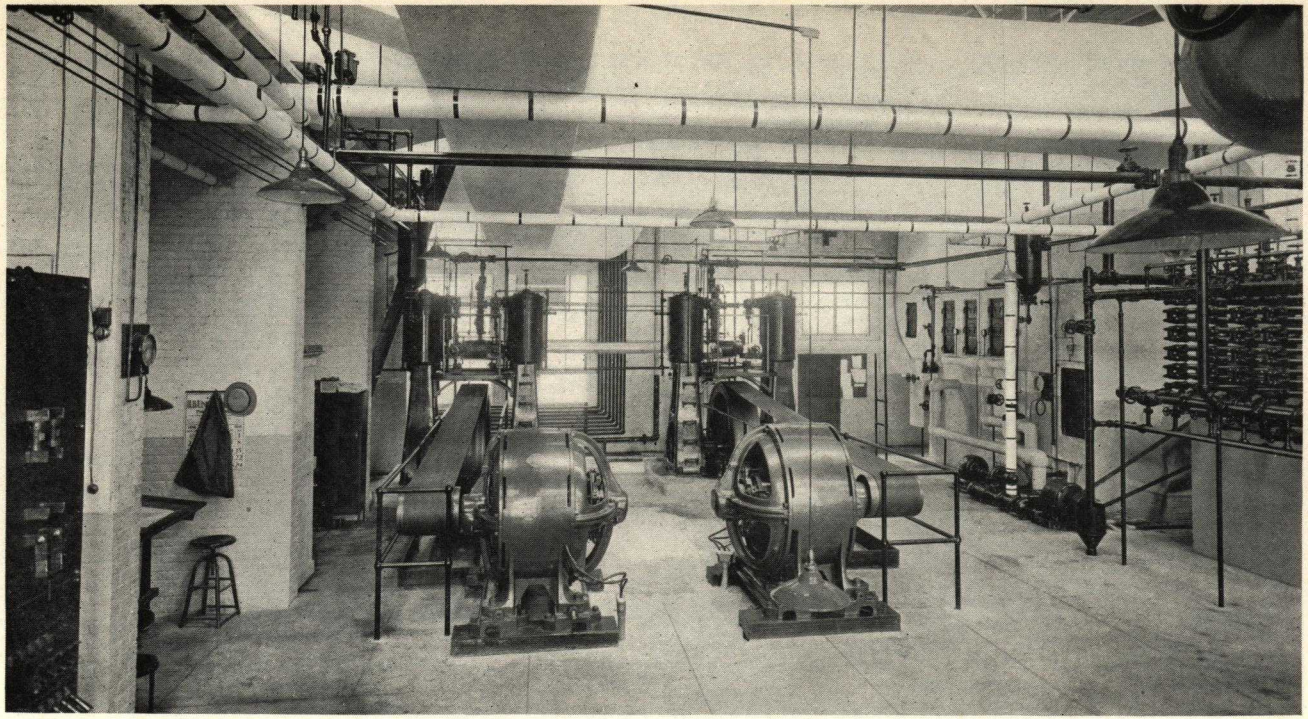
Carrier Baudelot Coils showing connections.

if desired, they may be placed in a separate room or building.

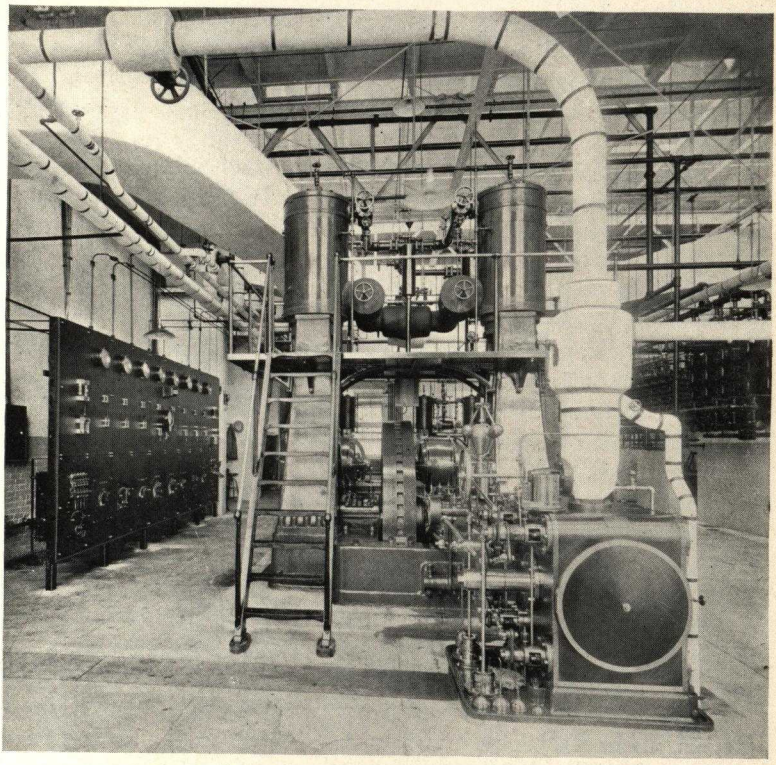
Liquid and suction headers with expansion and purge valves, and properly proportioned for the work to be done are supplied with all of our coils. The operating valves are shown on page 51.

Refrigerating Machines. We supply either absorption or compression refrigerating machines, in the various horizontal, vertical, single or double-acting types as best suited to the conditions. These machines are not of our manufacture, but as our annual purchases total between one and two thousand tons, we procure prices from the best builders that often enable us to save money for our customers. Buying the refrigerating machine through us further doubly relieves the purchaser of all responsibility of harmonizing the various parts of the equipment.

In the selection of this equipment, we study the problem from every angle, with a view not only to accomplish a given result, but to do so with an initial expenditure and operating cost, including maintenance and depreciation, and a satisfaction that



Apparatus room of the Walco Co., Providence,R. I., showing on the right the Carrier Dehumidifier and the Condensers and in the center the two vertical two-column single-acting motor driven compressors also installed by us.



Another view of the Walco Company's apparatus room showing the vertical two-column single-acting steam-driven compressor. The entire air conditioning equipment of this firm was furnished, installed and delivered by us ready for operation.

give the best return for the expenditure. Our best salesmen are our customers, and an impressive list of them, to whom inquiries may be directed, will gladly be sent.

Dry Blast Towers. In the reduction of pig iron from ore the amount of coke consumed may be reduced as much as 10 per cent or more by dehumidifying the air used in blowing the furnace. In steel plants where there is a heavy demand for gas from the furnaces to be used under boilers, etc., the saving is not so great as with merchant furnaces.

The tower is the most efficient type of cooling apparatus, as it gives a perfect counter-current effect. Water, sufficiently cold to perform a considerable part of the cooling, can usually be

obtained from natural sources for the first stage of the work. Even where the water has to be cooled by refrigeration, a very high ammonia suction pressure can be used, thereby greatly reducing the size of ammonia compressor required, and the power consumed.

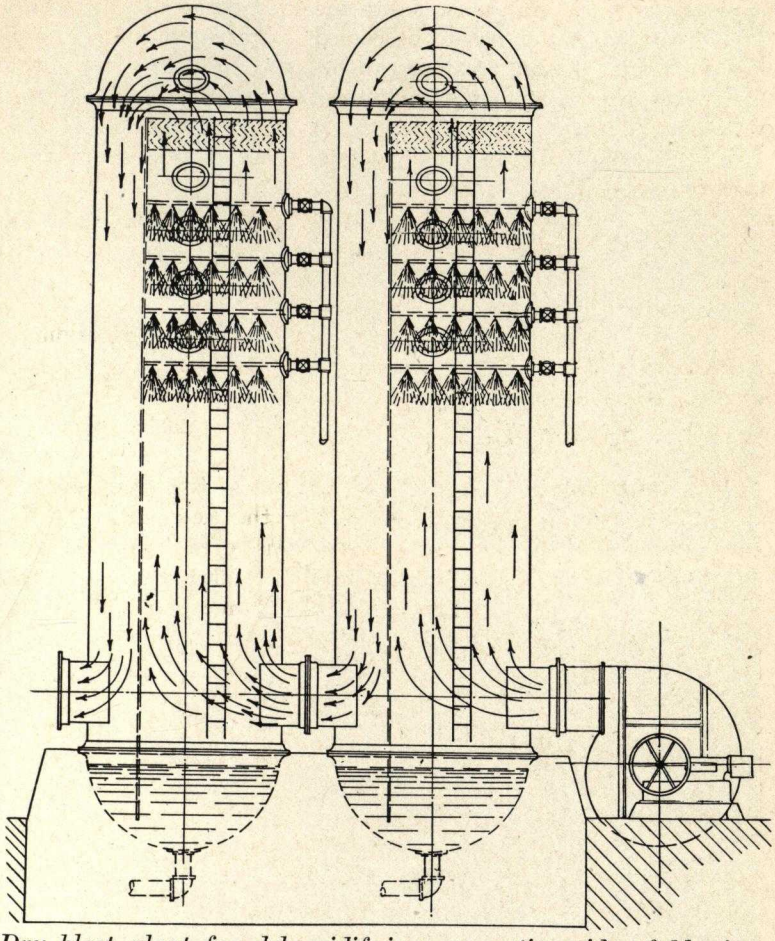
If the dehumidifying is being done on the suction side of the blowing engine, and much less than two and a half grains of water vapor, corresponding to a dew point of 36 degrees Fahr., is to be carried by the air leaving the apparatus, water cannot be employed in the final stage. In such cases a spray of calcium brine is employed in the final stage.

The advantages over the coil or surface type of dehumidifier for this work are: *first,* reduction in amount of power required; *second,* reduction of first cost; *third,* reduction in space required, and *fourth,* the constant and uniform condition of the air supplied to the furnace.

The cut on page 57 shows a set of cooling towers for a dry blast plant for a blast furnace where the dehumidifying is done before the air is compressed, making use of water in the first stage to reduce the air to a temperature of 39 degrees Fahr., and of calcium brine in the second stage to further reduce it to 24 degrees Fahr. and a content of one and a half grains of moisture per cubic foot.

In blast furnace work a great saving of refrigeration is effected where the moisture can be removed after the air has been compressed. The dew-point for a given weight of water vapor in a given space is dependent upon the vapor pressure, and not upon the air pressure. By compressing the mixture of air and water vapor, the dew-point required for the same final relative weights of vapor and air will be raised. To illustrate: If it is desired to reduce the water vapor to two grains per cubic foot of free air, and the dehumidifying is done at atmospheric pressure, it is necessary to reduce the air to a temperature of approximately 30 degrees Fahr. If, however, the air is compressed to double the absolute pressure, it will occupy only one-half the space, and it will be necessary to cool the air only to a dew-point of approximately 50 degrees Fahr. in order to reduce the vapor content to the same weight per pound of air.

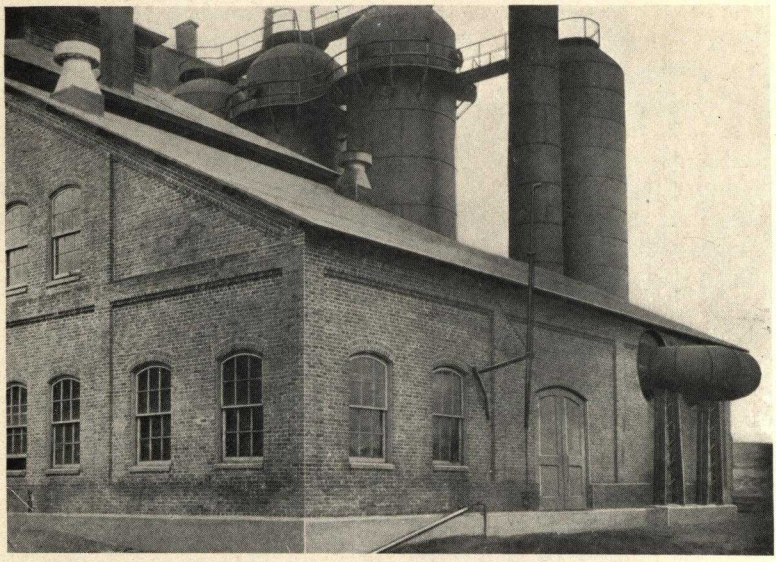
The total work required after compression is much greater, as the heat of compressing the air must be removed in addition to that necessary to produce the required condensation. The elevation of the temperature plane not only allows of a high suction pressure at the ammonia compressor, with the resultant increased economy, but it also makes it possible to do a very large portion of the work by water from any convenient source, such

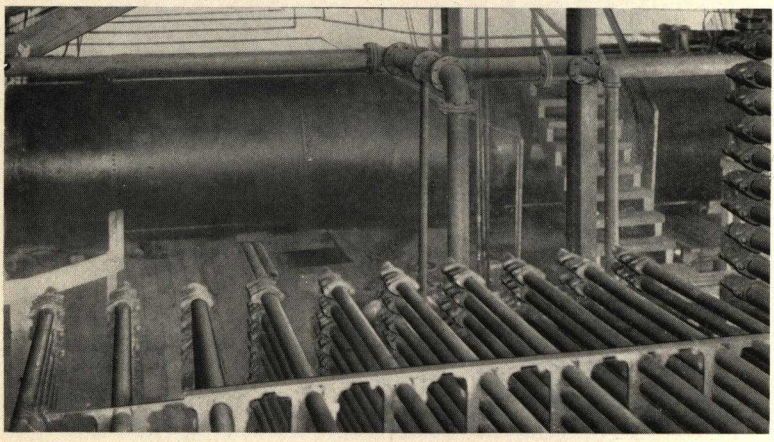


Dry blast plant for dehumidifying on suction side of blowing engine.

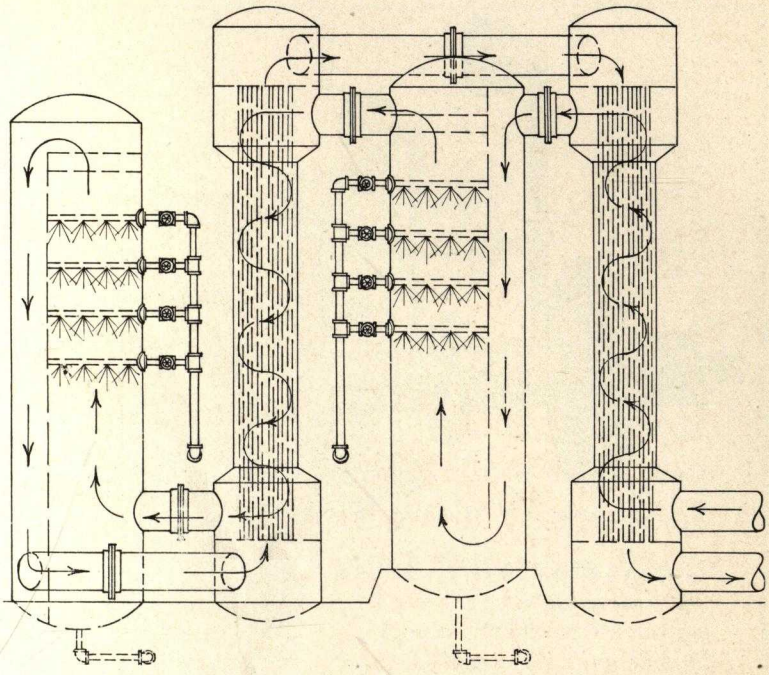
as rivers, lakes or wells. The colder the water available, the less refrigeration is required. One reason this method has not been more popular until recently is that any variation in the air pressure causes a variation in the amount of moisture carried to the furnace.

The system of dehumidifying under pressure which has been designed for blast furnace application, invented by Mr. John B. Miles, provides for varying automatically the dew-point temperature of the air leaving the dehumidifier, in relation to the variations in the air pressure to procure a constant relation of the weight of water vapor and air.





The Carrier Horizontal Cylinder Direct-Spray Dehumidifier installed at the plant of the Northern Iron Co., Standish, N. Y., to dehumidify air passing from the blowing engines to the blast furnaces. The dehumidification is accomplished after the air has been compressed to 10 pounds gauge pressure, making it necessary to cool the air only to a dew-point of 41 degrees Fahr., while, if done before compression, to produce the same results, one and three-fourths grains per cubic foot, would require a dew-point temperature of 28 degrees Fahr.
The first stage of this apparatus uses water from a nearby stream, and the second uses artificially cooled water.



Carrier Dehumidifier with interchanger, for use in compression side of blowing engine in blast furnace work.

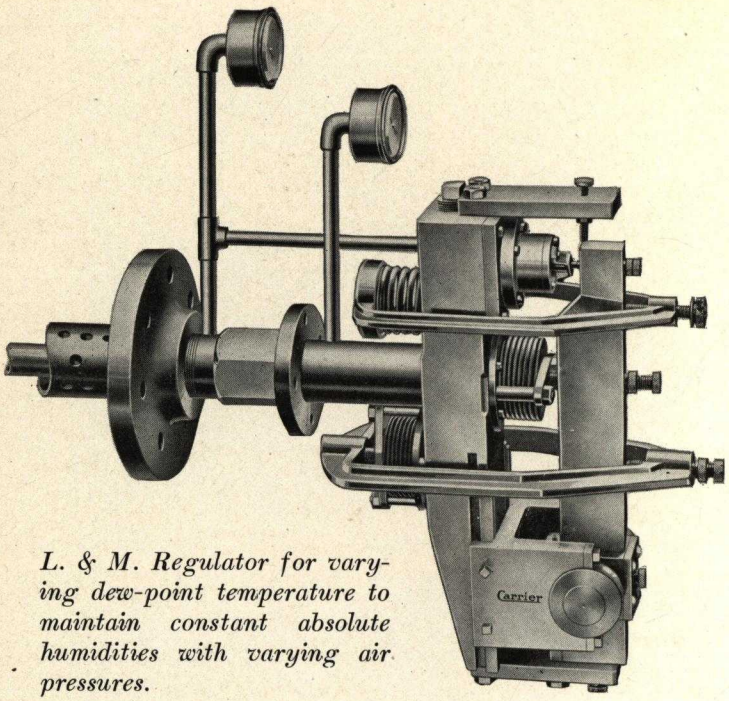
The relation between the air pressure and the dew-point required is a variable, and an automatic regulator invented by Messrs. Murphy and Lyle of this Corporation, and is used to maintain this regulation. This regulator is shown on page 60.

By interposing an interchanger between the first stage using natural water and last stage using refrigeration, 30 to 35 per cent of the remaining work can be done without costing more than refrigerating apparatus displaced, and with no operating expense.

The third stage, using water or brine which is artificially cooled, reduces the air to final dew-point required. The dew-point, however, is not so low as with an atmospheric pressure.

With compressed air the efficiency of the interchanger is greatly increased, due to a greater density. With an interchanger having the same first cost as the refrigeration which it displaces, the refrigeration required is reduced to 30 to 40 per cent.

The principal advantages of dehumidifying for blast furnaces on the compression side of the blowing engine are: *first*, the large amount of work which can be done by water from natural sources; *second*, the high efficiency of an interchanger; *third*, the



L. & M. Regulator for varying dew-point temperature to maintain constant absolute humidities with varying air pressures.

high ammonia suction pressure; *fourth,* a very low first cost; *fifth,* small space required, and *sixth,* low cost of maintenance.

Bulletin No. 100

Carrier Humidifying Apparatus

Every man interested in humidifying should read this booklet which explains air conditioning in general and also such details in particular as proper air supply; fixing the amount of water vapor; heating; cooling; securing various humidities from one apparatus; air distributing systems based upon ordinary galvanized iron ducts, interior risers, hollow pilasters, central vertical flues, etc.; automatic dew-point control; proportioning fresh and return air, etc.

Further detailed description includes features of the Carrier Humidifier—spray chamber, piping and nozzles, water pumping, heating and straining methods, air-distributing baffles, fan, water-eliminating baffles, fresh and return air dampers, compressed air system and safety valves for operating the dew-point control, etc.

Your copy will be mailed on application and if you tell us at the same time the exact humidity conditions you desire in your plant our engineers will advise to your best interests and without charge.

No Humidifying, Heating, Cooling, or Ventilating Problem will be too complex if you avail yourself of Carrier Engineering Service.

By securing our cooperation on difficult humidifying work you save time and money and protect yourself against faulty or unsuitable selection and proportion of parts.

Our claim to your consideration is based upon extensive research and experimentation by America's pioneer engineers in this line, upon long experience in design and installation, upon enviable records made by hundreds of prominent installations made under our direction, and last but not least, upon our eagerness to keep every client permanently pleased.

A conference between your engineers and ours may show big differences between what you now contemplate and what you should have.

Some industries we have served and a representative installation in each

Alpacas
Farr Alpaca Company, Holyoke, Mass.

Artificial Silk
Viscose Company, Marcus Hook, Pa.

Assembly Halls
Masonic Temple, Philadelphia, Pa.

Automobile Tire Fabrics
Brighton Mills, Passaic, N. J.

Automobiles
Ford Motor Company, Detroit, Mich.

Bakeries
Gordon-Pagel Company, Detroit, Mich.

Baking Powder
General Chemical Company, Undercliff, N. J.

Banks
J. P. Morgan & Company, New York.

Breweries
Piel Brothers, Brooklyn, N. Y.

Candy
Hershey Chocolate Company, Hershey, Pa.

Capsules
Eli Lilly Company, Indianapolis, Ind.

Cartridges and Rifles
Winchester Repeating Arms Company, New Haven, Conn.

Celluloid
Celluloid Company, Newark, N. J.

Chemicals
Chas. Pfizer & Co., New York

Chewing Gum
Beechnut Packing Company, Canajoharie, N. Y.

Cigarette Blending
Schinasi Bros. Branch, Tobacco Products Corporation, New York.

Cigarettes
American Tobacco Company, Butler-Butler Branch, New York.

Cigars
International Cigar Machinery Company, Brooklyn, N. Y.

Clubs
Royal Automobile Club, London, England

Cold Storage
Armour & Co., Chicago, Ill.

Cotton Goods
Riverside and Dan River Mills, Danville, Va.

Cotton Yarns
Sharp Manufacturing Company, New Bedford, Mass.

Dress Shields
Kleinert Rubber Co., College Point, Long Island.

Drugs
American Druggists Syndicate, Long Island City, N. Y.

Dry Blast for Iron Furnace
Northern Iron Company, Standish, N. Y.

Dry Plates
Defender Photo Supply Company, Rochester, N. Y.

Dyeing and Bleaching
United Piece Dye Works, Lodi, N. J.

Egg Storage
Merchants Refrigerating Company, Jersey City, N. J.

Embroidery
Glenham Mills, Glenham, N. Y.

Films
Eagle Rock Manufacturing Company, Verona, N. J.

Food Products
Kellogg's Toasted Corn Flake Company, Battle Creek, Mich.

Furs
Jonas & Naumburg, New York

Granulated Tobaccos
Blackwells Durham Tobacco Co., Durham, N. C.

Hotels
The Baltimore, Kansas City, Mo.

Laboratories
Edison Laboratories, West Orange, N. J.

Lithographing
Curtis Publishing Company, Philadelphia, Pa.

Macaroni
Port Huron Milling Company, Port Huron, Mich.

Machine Shops
Metz Motor Car Company, Waltham, Mass.

Malt Houses
Albert Schwill Company, Chicago, Ill.

Metal Enameling
Republic Metalware Co., Buffalo, N. Y.

Motion Pictures
Vitagraph Company, Brooklyn, N. Y.

Paper
Crocker, McElwain Company, Holyoke, Mass.

Photographic Paper
Ansco Company, Binghampton, N. Y.

Powder
E. I. Dupont DeNemours & Co., Wilmington, Del.

Power Houses
General Electric Company, Schenectady, N. Y.

Provisions
Armour & Company, Chicago, Ill.

Residences
Charles G. Gates, Minneapolis, Minn.

Rubber
Miller Rubber Company, Akron, Pa.

Serums
Great Western Serum Company, Chicago, Ill.

Silk Ribbons
John B. Stetson Co., Philadelphia, Pa.

Silks
Susquehanna Silk Company, Lewiston, Pa.

Silk Throwing
Klots Throwing Company, New York

Soap
Proctor & Gamble, Ivorydale, O.

Steel
Bethlehem Steel Co., South Bethlehem, Pa.

Testing Yarns
U. S. Appraiser's Warehouse, New York

Thread
American Thread Co., Fall River, Mass.

Time Fuse for Shrapnel
American Locomotive Company, Providence, R. I.

Tobacco
American Tobacco Company, Richmond, Va.

Trust Companies
Bankers' Trust Company, New York

Underwear
Northwestern Knitting Mill, Minneapolis, Minn.

Worsted Yarns
Passaic Worsted Spinning Company, Passaic, N. J.

Worsteds
Gera Mills, Passaic N. J.

Yeast
Corby Company, Washington, D. C.

Carrier
Engineering Corporation

**Consultation,
designs,
construction,
equipment
and
installation
complete or in part**

Plants for Humidifying, Dehumidifying, Cooling, Drying, Air Washing, Automatic Temperature and Humidity Regulation

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